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THE

# TEA QUARTERLY

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THE TEA RESEARCH INSTITUTE
St. Coombs, Talawakele,
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THE TEA QUARTERLY

**Vol. 32** **September, 1961** **Part 3**

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# EDITORIAL

In this issue we publish the last four papers from the January Biennial Conference, by Drs Visser, Joachim, Mulder and Hutchinson. We have also the balance of the answers to planters' questions. This completes the Conference proceedings.

The second of Dr Visser's papers on interplanting in tea is likely to stimulate controversy. He marshalls the evidence regarding circumstances in which perennial tropical crops—including tea—may have a higher ceiling of yield when unshaded and heavily manured than when shaded. The information available does not justify any practical recommendation and, in order to avoid misunderstanding by partial or unguarded quotation, we are copyrighting the article. But the evidence does justify us in starting trials. In order to cover as wide a range of conditions as possible, we invited co-operation and have had a most encouraging response from Agency Houses and from the limited number of Superintendents that we have discussed the matter with. It will take some time to start the trials. Further information will be given later.

This issue is notable in that Mr Tolhurst recommends changes in the composition of fertilisers for mature tea and for adolescent tea.

Essentially, for mature tea the change is a reduction in the proportion of phosphate in the mixture and of the amount of phosphate applied per acre. There are variations in potash according to the amount desired. The new series of mixtures is called the T 700 series, including T 725 and T 750. It is considered that the reduction in phosphate is very unlikely to harm tea, that it may even do good in some circumstances, and that it will save a little money.

Dr Visser introduces the subject of potato-planting as a means of contributing to the cost of replanting tea and at the same time assisting the Island's economy. The main danger is wilt disease and this danger is least where there has for many years been no crop that carries this disease. It is not to be expected that most tea estates can raise more than one crop before the disease becomes ruinously destructive.

Letters to the Editor are coming in nicely. They do stimulate discussion and thought. It should be understood that they represent the opinions of the authors and not necessarily of the T.R.I. Naturally we should not publish a letter advocating planting tea upside down but the letters that are accepted are not censored by us, even when we do not entirely agree with something that is said.

News items at the time of going to press are the arrival of Dr H. N. Hasselo on June 10th to set up the new Agronomy Division; and the passage of an amending act through the House of Representatives and the Senate increasing the Tea Research Cess to 1 cent per pound from 19th June, 1961.

# *INTERPLANTING IN TEA: 2—THE INTERACTION OF SHADE WITH FERTILIZER APPLICATIONS

T. Visser

## Introduction

Walter (1950), Portsmouth (1951), and Visser and Kehl (1956) used an ecological argument in favour of the use of shade in tea, namely that tea is a "shade-loving" plant, because the tea in its natural habitat grows under shade.

However, man has rarely paid much heed to such crude ecological arguments in the development of his crop plants, or he would not cultivate his soil, weed his crops, or apply manure to them. This is also true for tea; the conditions under which it is commercially grown today are very different from those of the tea growing in the forest, for it is pruned, plucked, manured, and cultivated.

Accordingly, the habit of the tea tree has been fundamentally changed by its artificial conversion into a leaf-producing bush. Therefore, it may well be asked whether it is necessary, or under what conditions it is useful, to give a poor imitation of one single aspect of a forest, namely, by sparsely interplanting the tea with shade trees.

The shade question is not new but it has recently come into the limelight again. De Weille (1959) in Indonesia discussed shade trees especially in connection with blister-blight control and concluded "that shade removal can be carried out and there is no need to fear any damage by sun or wind". Wight (1959 a, b, c), in a series of articles, extensively reviewed the work done in Assam, demonstrating the complex nature of the interaction between shade and fertilizer application and the importance of differences in reaction of different *agrotypes* of tea. On the whole, Wight's observations indicate that the use of *Albizzia chinensis* shade trees under Assam conditions is to be favoured for both agricultural and economic reasons.

Lately Child (1960), in East Africa, reviewed many of the historical data on the shade-tree tradition, as well as observations made on the effect of shade trees in Kenya and Nyasaland. He reached no conclusions but indicated "the danger of making or of accepting dogmatic assertions" on the shade question.

I have recently discussed several aspects of shade trees, cover crops, and weeds, in relation to soil moisture, mobilization of and competion for nutrients, and organic matter (Visser, 1961 a). In the present paper I review and discuss the influence of shade *per se* and its relation to fertilizer applications.

## 2. Shade and manuring with special reference to nitrogen

The majority of experiments on shade and manuring have been carried out by the Tocklai Experiment Station over a period of 30 years. In order to distinguish

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the effects of shade itself from effects of shade plus root competition acting together, bamboo screens were used and compared with normal shading by growing trees. The experiments indicated that generally the interaction between nitrogen and shade is the more important one.

Table 1 gives two examples derived from graphs (of different trials) given by Dutta, Basu and Sharma (1958) and Wight (1959b) on the effects of natural and of artifical shade in relation to increased nitrogen applications.

TABLE 1.—*Annual yield of tea (in lb. per acre) under natural shade (Albizzia chinensis) and artificial shade (screens, giving 50% light intensity) as affected by nitrogen application (Assam)*

Tea planted in 1932; *Albizzia chinensis* in 1942.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Period | Treatment | Zero N | 90 N | Gain due to N |
| 10 years (1942–'51) | Shade trees | 900 | 1120 | +220 |
| | No shade | 752 | 1084 | +332 |
| | Gain due to shade | +148 | +36 | |

Tea planted in 1920: screens erected in 1951

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Period | Treatment | Zero N | 80 N | Gain due to N |
| 7 years (1951–'57) | Screens | 790 | 790 | 0 |
| | No shade | 480 | 880 | +400 |
| | Gain due to shade | +310 | —90 | |

Table 1 shows that the shaded tea was more productive than the unshaded when no nitrogen was given (Columns 3); but with 80 lb. or 90 lb. N, the unshaded tea was about the same as the shaded. The effect of N was thus far more beneficial with unshaded tea than with shaded (Columns 5). With 80–90 lb. N, the unshaded tea had caught up with the shaded; the results suggested that with still more N, unshaded tea would gain still more and give a higher ceiling to the crop.

In a sense, shade thus appears to be equivalent to a certain amount of nitrogen, in these two cases about 30 to 60 lb. N per acre. In another long-term trial initiated by Cooper (Wight, 1959a) shaded tea without nitrogen was found to yield nearly as much as unshaded tea which had received on an average 84 lb. N yearly.

The influence of shade *per se* has been investigated at Tocklai in many other trials both on unmanured tea (Wight, Barua, Green & Barua, 1958; Barua 1956, 1957 and 1960) and in the presence of different dosages of nitrogeneous fertilizer at varying light intensities (Dutta & Heath, 1954; Dutta & Basu, 1956, 1957; Dutta, Basu & Sharma, 1958). These trials showed basically the same results as those presented in Table 1, namely that the yield of the tea depends both on the shading density and the nutrient supply (soil fertility).

Shade-tree and nitrogen effects have also been investigated by the Tea Research Station in Nyasaland, the results being given in Tables 2 and 3 (Anon. 1954, 1955, 1956, 1957, 1958, 1959 and 1960).

TABLE 2.—*Annual yield of mature tea (lb. per acre), unshaded and shaded by Albizzia gummifera, with and without nitrogen (Nyasaland)*

Tea planted in 1932, *Albizzia gummifera* in 1949.

| Treatments | Period I: 52/53—55/56 | | | Period II: 56/57—58/59 | | |
|---|---|---|---|---|---|---|
| | Zero N | 80 N | Gain due to N | Zero N | 80 N | Gain due to N |
| Shade trees ... | 510 | 629 | +119 | 755 | 907 | +152 |
| No shade ... | 342 | 602 | +260 | 672 | 1039 | +367 |
| Gain due to shade ... | +168 | +27 | | +83 | —133 | |

TABLE 3.—*Annual yield of young tea (lb. per acre) under different shade-tree species (similarly manured) (Nyasaland)*

Tea planted in 1951, trees in 1952.

| Treatments | Perod I: 1953/54—55/56 | | Period II: 56/57—58/59 | |
|---|---|---|---|---|
| | Yield | Gain due to shade | Yield | Gain due to shade |
| No shade ... | 305 | — | 1,185 | — |
| *Grevillea robusta* ... | 336 | +31 | 1,045 | —140 |
| *Albizzia gummifera* ... | 336 | +31 | 856 | —329 |
| *Gliricidia maculata* ... | 280 | —25 | 778 | —407 |

Table 2 shows the same tendency as was observed in the Tocklai trials, namely that shaded tea gives a higher yield than unshaded tea in the absence of nitrogen, but that nitrogen applied to unshaded tea increases its yield more than that of shaded tea. The yields of the manured tea over the first period of 4 years are about the same, irrespective whether or not shade is present, while that of unshaded tea over the second period—at the end of which the shade trees were ten years old—was significantly higher than that of shaded tea. This is presumably due to the fact that as the trees grow older, the light intensity under them is reduced and competition increases. In this experiment shade trees were about equivalent to 40–50 lb N.

Table 3 demonstrates a similar effect on young tea of the age of the shade trees. During the first period—at the end of which the trees were five years old—the effects of the trees were small (of the order of 8–10%). During the second period of three years, all shade-tree species depressed yield, particularly *Gliricidia* and *Albizzia*. These trees had by that time formed a closed canopy, so that competition for light occurred and, especially in the case of *Albizzia*, competition for moisture too (Anon. 1960). The fact that yield was depressed least by *Grevillea* is probably due to the fact that this tree neither provides such a heavy shade as *Gliricidia*, nor competes so severely for moisture (and nutrients) as *Albizzia*.

Another example of the effect of shade on nitrogen responses is given in the form of a graph which presents the summarised results of two manurial trials carried

out by the Tea Research Institute of East Africa (Kericho) and the Tea Research Institute of Ceylon (St Coombs). At each location the nitrogen responses in the one experiment were investigated on tea under *Grevillea robusta* and in the other trial in the absence of shade trees. The Kericho trial represents yields over a 4 year cycle (Goodchild, 1956; Goodchild and Foster-Barham, 1957, 1958, 1959, 1960). The St Coombs trial without shade represents average yields over the 2nd cycle—20 to 40 lb. N—and 4th and 5th cycle—40 to 80 lb. N (Eden, 1949b); the figures relating to shade present yearly averages of the 3rd and 4th cycle of an experiment initiated by Eden (1941, 1943).

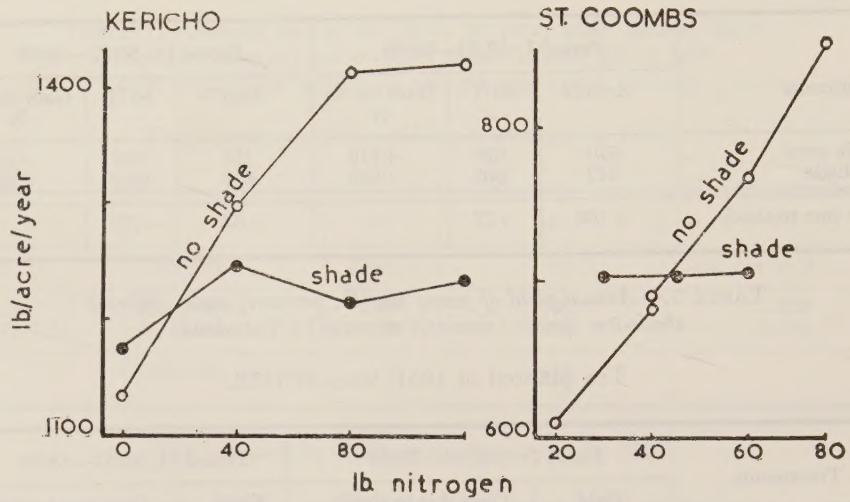


Figure 1. Nitrogen responses of tea under *Grevillea robusta* trees and of unshaded tea—Kenya and Ceylon

Although Figure 1 presents data from two different trials, they allow a qualitative comparison. It is shown that the trend is the same as mentioned before, namely *that unshaded tea responds better to nitrogen than shaded tea.* The yields of the unshaded tea increase linearly with the nitrogen dosage up to 80 lb per acre in both instances. The yield of the shaded tea, on the other hand, is not much affected by the nitrogen dosage.

The observed interaction between shade and manurial application is a general one and it applies to other crops that are traditionally shaded, such as cacao.

Table 4 represents the results obtained by Cunningham and Lamb (1958, 1959) in Ghana on 10-year old cacao, unshaded and shaded, unmanured and manured over the last three years with N, P, K and Mg.

TABLE 4.—*Annual yields of cacao (lb./acre), unshaded and shaded by Gliricidia maculata, with and without fertilizer (Ghana)*

| Treatment | No fertilizers | NPKMg | Gain due to fertilizer |
|---|---|---|---|
| Shade trees ... | 615 | 869 | +254 |
| No Shade ... | 1,079 | 1,574 | +495 |
| Gain due to shade ... | —464 | —705 | |

It will be seen from Table 4 that the unshaded cacao yielded markedly more than the shaded, even in the absence of manuring. This indicates both a high soil fertility and shade so heavy as to limit nutrient uptake. Again responses to manuring were higher without than with shade. Comparable trends were also observed in Trinidad on a spacing-cum-manuring trial, unshaded and shaded by shade trees (Havord, Maliphant & Cope, 1954, 1955; Maliphant, 1959a) and in a manurial trial in which young cacao was grown under light intensities varied by means of bamboo screens (Evans & Murray, 1952; Murray 1953, 1954, 1955a, 1958). It appeared from the latter experiment that with light intensities less than 50%, light was limiting yield; with more than 50% light there was a drop in yield of the unmanured plots but an increased yield of the manured plots indicating that then nutrient availability was limiting yield. In this trial the cacao trees in the early stages after planting grew better under shade than without.

TABLE 5.—*Annual yield of cacao under shade (Erythrina poeppigiana) and artificial shade (screens, giving 50% light intensity) with and without fertilizer (Trinidad).*

Yield in lb./acre (6th crop year)

| Treatment | No fretilizer | NPK | Gain due to fertilizer |
|---|---|---|---|
| Shade trees ... | 924 | 1,215 | +291 |
| No shade ... | 610 | 1,488 | +878 |
| Gain due to shade ... | +314 | —273 | |

Yield in No of pods/12 trees (4th Crop year)

| Treatment | No fertilizer | NPK | Gain due to fertilizer |
|---|---|---|---|
| Screens ... | 66 | 114 | + 48 |
| No shade ... | 26 | 152 | +126 |
| Gain due to shade ... | +40 | —38 | |

Table 5 is an example of the trends of young cacao some years in bearing. It presents the results of two treatments—not manured, and manured with NPK—of the trial under shade trees (Maliphant, 1959a) and of the trial under screens (Murray, 1955a) respectively.

It can be seen from Table 5 that the interaction between shade and fertilizer application with respect to cacao is the same as that observed for tea (*see* Table 1), irrespective of whether the light intensity was reduced by shade trees or by screens. In both instances, shade significantly increased yield in the absence of fertilizers but decreased it when N, P and K were applied. The gains due to fertilizer applications were about three times as high for unshaded cacao as those for shaded cacao.

A recent review by Dierendonck (1959) refers to experiments carried out in Central and South America which indicate the existence of a similar relationship between shade and manuring with coffee as found for tea and cacao. Yield responses to fertilizers, particularly nitrogen, by unshaded coffee were observed to be much higher than corresponding responses under shade.

### 3. Shade and manuring, with special reference to phosphate and potash

As regards shade and phosphate applications, a negative interaction has been found in several trials carried out by the Tocklai Experimental Station (Dutta & Heath, 1954; Dutta, Basu & Sharma, 1958; Wight, 1959a & c). It appeared that phosphate increased the yield both under natural and artificial shade, while decreasing it in full daylight. Wight (1959a, 1959c) suggested that the phenomenon is perhaps in some way connected with mycorrhiza, as their development may be affected by the light intensity as shown by Björkman (1942) for *Pinus* and *Picea*.

On the other hand, the relation between shade and phosphate may have other causes, though not necessarily related to shade trees, as inferred by Dutta *et al* (1955 & 1956) because the interaction was also negative under artificial shade. It seems possible that the depressing effect of increased phosphate is partly associated with weed growth—particularly in the case of annual pruning—for weed growth is reduced by shade and greatly enhanced by phosphate (Eden, 1944, 1949a; Visser, 1961a).

These suggestions do not explain why a positive response to phosphate was found in an *unshaded* long-term trial at St Coombs (Eden, 1949b) and a negative response in *shaded* tea at Passara (Eden, 1949a; Portsmouth, 1954; Visser, 1957). Likewise, phosphate under shade had not a positive effect in all trials carried out in Tocklai; *e.g.* in a trial with different shade-tree species, phosphate (or potash) had no effect on yield either in the presence or the absence of nitrogen (Dutta & Heath, 1954; Dutta, Basu & Sharma, 1959).

Responses to phosphate in experiments carried out in East Africa (Eden 1953, 1954; Goodchild, 1955, 1956, 1957; Goodchild & Foster-Barham, 1957, 1958, 1959, 1960) were very small whether or not the tea was shaded; in two shaded trials, phosphate increased yield by 2 and 5%, in two unshaded trials by 1 and 1.5%.

In experiments on young cacao on Trinidad with and without shade trees (Maliphant 1959a), and under varying light intensities obtained by screens (Murray, 1954, 1955), phosphate responses were on the whole higher for unshaded than for shaded cacao.

With respect to potash applications and shade, it was found that potash responses of cacao under shade trees were higher than those of unshaded cacao (Havord, Maliphant & Cope, 1955; Maliphant 1959a), while potash applied to cacao under screens increased the yield above 50% light intensity and had its maximum effect at full sunlight (Murray, 1954, 1955a). The effect of potash on the yield of tea in trials carried out in East Africa was negligible, irrespective of the presence of shade trees. In the Tocklai experiments too, no interaction between shade and potash application was found.

It is evident from the foregoing that there is no clear-cut relation between shade on the one hand and potash and phosphate responses on the other. Undoubtedly both soil conditions and the amounts and the proportions of the fertilizer mixtures play an important part. When mineral supplies are adequate, manurial effects may be absent irrespective of shade; the effects may even be negative, if an abundance of one mineral leads to a decreased availability of the other.

On the whole, it would appear that nitrogen is the most important element in relation to light intensity and is probably in most instances the limiting factor rather than potash and phosphate. It seems likely that these latter nutrients (and others) will become limiting only if their availability in the soil is limited (or unbalanced) and nitrogen requirements are satisfied.

## 4. Effect of shade and fertilizer application on the composition and characteristics of leaves

4.1. Mineral composition.—As regards the percentage mineral content, Blackman and Rutter (1947, 1948, 1949) made an extensive study of bluebells (*Scilla non-scripta*). They found that shading increased the percentage contents in the leaf of N, P and K, the last being most affected. In all but one instance, the effects of increased nutrient supply on the percentage content of any of the elements were of much the same magnitude at all levels of light intensity. The exception was in one trial where the effect of additional potash decreased with reducing light intensity.

Leaf analysis of young cacao in trials under artificial shade (Murray, 1953) and under natural shade (Maliphant, 1959b) showed that light intensity markedly affects mineral levels in the leaf. The overall effect of shade was to increase the levels of N and particularly that of K. However, similar levels in unshaded plants could be produced by additional applications of N and K.

In Murray's trial the percentage P–content was not much affected by either light intensity or phosphate application. In the experiment by Maliphant, phosphate fertilizer markedly increased leaf P–content in the absence of shade. In this trial nitrogenous fertilizer depressed the P–content and potash decreased the N–content of the leaf more markedly in the absence of shade than with shade. Results similar to those of Murray were also obtained by Tanada (1946) for coffee seedlings grown under different light conditions in water cultures. It was found that N and K contents of shaded leaves were much higher than those of unshaded leaves, while P–contents were little affected by the light intensity. Dierendonck (1959), in a review of the effect of shade and manuring on coffee, concluded that leaf-nitrogen levels of unshaded coffee can be potentially as high as, or possibly higher than those of shaded coffee when sufficient nitrogen is available in the soil.

Barua (1957) found in tea artificially shaded by screens that the percentate N–content of plucked shoots significantly increased, though the increase was small, with reduced light intensity. Neither the dosage rates (75 and 150 lb N) nor their interaction with light intensity had significant effects.

It would appear that the tendency of unshaded plants to contain a lower percentage of minerals than shaded plants is mainly an indication of the insufficiency or lack of balance of the nutrient supply in relation to the increased demands of the more rapid metabolic processes in the plant.

4.2. Leaf characteristics and quality.—With regard to the influence of light on the leaves, it appears that increased light intensity generally reduces leaf size (Murray 1953; Visser 1960) increased leaf thickness (Visser 1961b), and may also increase dry matter percentage (Murray, 1953, Barua 1957), though no such increase occurred in our experiments with tea (Visser, 1961b). Observations of De Haan (1949) on cropshoots of shaded and unshaded tea plants in pots showed that the total number and total weight of the shoots harvested from unshaded plants in comparison with shaded plants increase, while individual shoot-weight decreases with time. The shoots of the unshaded plants appeared to be shorter and tended to become dormant sooner than shoots of shaded plants. It was further observed that shaded plants tended to produce as much or more during the dry season, but less during the wet season than unshaded plants.

Acute nitrogen deficiency as indicated by the yellow flush of the unshaded plants is likely to have been partly responsible for the observed tendencies. De Haan

remarked that the effect of light is strongly dependant on soil fertility; plants on fertile soil react better to full sunlight than those on poor soil.

The influence of light intensity (40, 50, 100%) and of nitrogen (75 and 150 lb.) on the component parts and nature of cropshoots were investigated by Barua, Dutta and Gogoi (1958). The treatments had some effect, but the observed differences were so small that it seemed unlikely that they would have influenced the grades and appearance of made tea.

Tests were carried out at Tocklai during two seasons on the characteristics and valuation of unshaded and shaded (by screens) tea (Dutta & Heath, 1954; Dutta & Basu, 1957). No differences were found as regards quality, briskness, colour of the tip, and appearance of the made tea. In one of the tests, strength and colour of the liquor were greatly improved by shade, in the other test only the colour of the liquor improved while colour of the infused leaf was significantly better for teas grown under full light. The valuation of the made teas was the same, irrespective of shade, during both seasons.

Similar tests on the influence of the nitrogen level—0 and 100 lb N in one and 0, 40 and 80 lb N in another trial—showed no differences in the valuation of the made teas in relation to the rate of nitrogen application (Dutta *et al*, 1954 & 1957).

According to Gokhale (personal communication) previous tests done at Tocklai showed that nitrogen doses higher than 100 lb per acre decreased quality, but the possibility that this was caused by the fact that nitrogen applications only (and not those of P and K) were increased, may not be excluded. Keegel (personal communication) has no reason to assume that the relatively high nitrogen doses (in proportion to P and K) as applied in Ceylon have any effect on quality, but little is known for applications greater than 100–120 lb. per acre.

### 5. The influence of the removal of shade on yield

The effect of shade removal is of practical importance because it arises when old shade is removed and the field is left unshaded either permanently or temporarily until the newly-planted trees have formed a canopy again.

This problem was investigated in a trial by Evans and Murray (1952) and Murray (1953, 1954, 1955a) earlier referred to (*see* p. 117) and in which young cacao was grown at varying light intensities (obtained by screens) and different manurial treatments. Provision was made in this experiment for the removal of the shade on half the plots, which was done at the beginning of the 4th year after planting (Murray, 1955a). It appeared subsequently that the responses to shade removal were greater where the initial shade over the plots had been greater. The yields of plots previously shaded to allow 15, 25, 50 and 75% light intensity were on an average (all treatments) 108, 88, 71 and 51% higher respectively than those of their still shaded counterparts. The absolute yields of the previously shaded plots receiving a balanced NPK mixture were 35% (averaged for 15 and 25% L.I.) and 24% (averaged for 50 and 75% L.I.) higher than the yield of equivalently manured plots which remained unshaded throughout. This increase in yield following shade removal in comparison with permanently unshaded plots indicates that under the improved light conditions use is made of soil reserves or mineral reserves in the plant, accumulated during the shade period.

The amount of increase in crop was related to the mineral nutrition of the plant. Plants previously heavily shaded showed a response to nitrogen on removal of shade; plants previously growing at high light-intensities showed little response

to nitrogen, but a marked response primarily to potash, secondarily to phosphate. Murray (1955a) attributed the significance of this difference in response to nitrogen to the better growth and subsequent self-shading of the unshaded plants. Further, after nitrogen requirements are satisfied, the availability of other elements may become limiting.

A trial on the influence of shade removal on tea was carried out in Indonesia by Vink (1953). In this case an area of a field heavily shaded by *Leucaena* species was divided into four half-acre blocks, receiving the same manure and of which the shade trees were felled or lopped so as to provide 4 treatments; A=no shade (all trees removed), B=light shade, C=medium shade and D=heavy shade (all trees left) giving light intensities (measured by Van Emden & Laoh, 1953) of 100, 60, 39 and 18% respectively. Before shade was removed the blocks were pre-plucked for about 4 months and they gave similar yields per block. The subsequent yields obtained after partial or entire removal of the shade are presented in Figure 2.

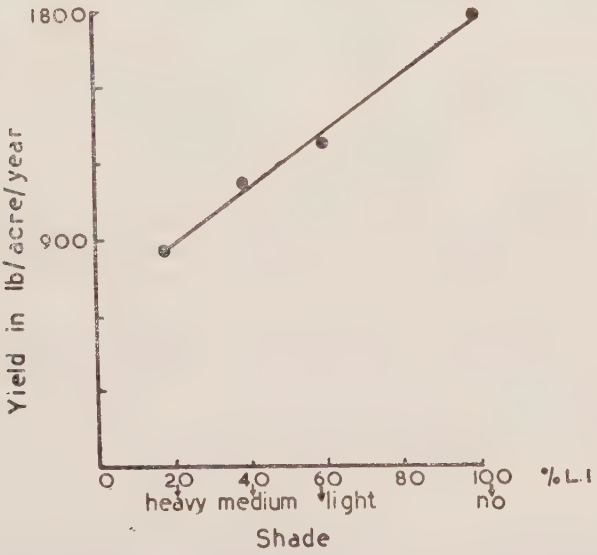


Figure 2. The effect of partial or entire removal of shade on tea yield (Indonesia)

Figure 2 shows that the yield increased in linear proportion to the increased light intensity. The complete removal of the shade approximately doubled the yield. The graph also suggests that yield increases will be greater when the light intensity before shade removal had been lower (as shown for cacao).

Both the trials on cacao and tea confirm the practical experience of estates in Ceylon that marked yield increases can be obtained following shade removal. The question is, however, can this increased yield be maintained?

A partial answer is provided by another experiment carried out in Indonesia (Vink, 1953). This trial was laid out in mature tea and consisted of 8 blocks, each of $1\frac{1}{4}$ acres. The medium to heavy shade, consisting of a mixed stand of *Albizzia falcata* and *Leucaena* species, was kept in 4 blocks and felled in 4 others (Jan. 1940). All blocks received only one manurial application of about 33 lb N and 40 lb $P_2O_5$ per acre in August 1940, and were plucked until June 1944 (Periods 1 and 2).

Thereafter, the field was rested until 1947 and then manured at 29 lb N + 17 lb $P_2O_5$ per acre per year. Experimental plucking was resumed from March 1949 until May 1950 (Period 3). At the end of this period most of the old *Albizzia* shade was removed and replaced by new trees and dadap cuttings; manuring was stepped up to 120 lb N + 70 lb $P_2O_5$ per acre per year because the unshaded bushes showed signs of deterioration. Experimental plucking was done from November 1950 until February 1950 (Period 4).

TABLE 6.—*The long-term effects of shade removal on yield (lb./acre) of mature tea, as affected by under-manuring and resting (Indonesia)*

| Period | Shaded | Unshaded | Gain or loss due to shade |
|---|---|---|---|
| 1. April '40—Dec. '41 ... | 613 | 1,057 | —444 (73%) |
| 2. March '42—May '44 ... | 715 | 711 | + 4 ( 1%) |
| 3. March '49—May '50 ... | 1,017 | 952 | + 65 ( 6%) |
| 4. *Nov. '50—Feb. '52 ... | 1,209 | 1,062 | +147 (12%) |
| Total ... | 3,554 | 3,782 | —228 ( 6%) |

**"Shaded" plots during Period 4 were actually virtually unshaded as the old trees were felled just before plucking started.*

Table 6 shows again a highly increased yield over the first year after shade removal (1), followed by a decrease in subsequent years (2) when shaded and unshaded tea yielded the same. After resting (3), the yield of the shaded tea was slightly higher than that of unshaded tea, which difference increased somewhat in the fourth period (4).

These trends are probably largely due to insufficient manuring, which had been virtually negligible in relation to the yields obtained during the first 10 years of the experiment. Under such conditions it is no matter of surprise that, over this period, shaded tea produced nearly the same yield as the unshaded tea. The nutrient requirements of the latter would have been much higher than those of the former, as all experiments so far described have shown.

The increased yield of the shaded tea as compared with the unshaded tea during the fourth period actually reflects the immediate effect of removing shade in the so-called shaded plot, as most of the shade had been removed at the start of this period. As the increased yields for the shaded and unshaded tea amounted to 18 and 12% respectively (period 4 versus period 3), one might say that two thirds of the increase was due to increased manuring and one third due to the removal of shade trees.

By and large, the indications are that the initial increased yield of the unshaded tea over that of shaded tea can be maintained if the tea is properly manured throughout. Improved light conditions will lead to a higher rate of metabolic activity in the plant, requiring a greater supply of nutrient.

## 6. Discussion

The foregoing review of experiments carried out on tea in particular, and also on cacao and coffee, leave not a shadow of doubt that shade and nutrient effects are interrelated phenomena. On the whole, it would seem that these traditionally shaded crops can produce higher yields in full sunlight than under shade trees,

*provided the nutrient supply is increased.* The depressing effect of shade trees on fertilizer responses is mainly due to the influence of shade *per se*; the trees as such play a secondary role.

The interrelation between light intensity and fertilizer responses is a fundamental physiological phenomenon as can be inferred from observations of White (1937) on cultures of *Lemna minor* grown at various light intensities and nitrate concentrations. It appeared that the optimal nitrate concentration rose with increasing light intensity and fell with decreasing light intensity, the optimal light intensity also decreased or increased with the level of the nitrate concentration. Similar observations were made by Murray (1954, 1955a, 1958) on artificially shaded cacao, while earlier it had been noted by Blackman and Rutter (1947) and Blackman and Wilson (1951b) in experiments with bluebell (and sunflower) that a marked interdependence existed between nutrient effects and shading, the nutrient effects being greatest at the higher light intensities.

Whether a plant will react favourably to shade or not is also dependant on the soil fertility, as is pointed out by Murray (1955b) with respect to cacao. In Grenada, on fertile soils and with generous manuring, high yields are obtained without shade—as was also observed by Cunningham and Lamb (1958, 1959) in Ghana; on the poorer clay soils of Trinidad, shade is necessary but yields are far lower. Likewise, Barua (1960) observed that although tea growing in (unmanured) good soil—as indicated by its nitrogen-status—produced the highest yields in full daylight, tea in (unmanured) soil of low fertility yielded best at a reduced light intensity.

It is thus evident that shaded plants have lower nutrient requirements, as is also suggested by the fact that shade has often been found to reduce nutrient absorption (derived from a literature review by Blackman and Rutter, 1949). The extent to which shade depresses nutrient uptake, notably that of nitrogen, may be linked with nitrogen availability. Both the observations of White (1937) with *Lemna minor* and of Gast (1937) with *Pinus sylvestrus* showed that nitrogen uptake (and growth) at reduced light intensity is more depressed when the nitrogen supply is greater. This also offers a partial explanation for the observation that the optimal nitrogen application for shaded tea is very much lower than that for unshaded tea (Dutta, Basu & Sharma, 1958; Barua, 1956 & 1960).

Shade reduces photosynthesis and thus slows down the metabolism of the plant, with the result that less mineral nutrient is required per unit of time than when a plant is unshaded. Without shade, photosynthesis will be rapid and, if the minerals are not limited, a high metabolic rate can be achieved, leading to high yields. On the other hand, if the absorption rate of a plant is restricted by a limited or unbalanced nutrient supply and thus the increased demands of the plant cannot be met, internal deficiencies will occur. This is also substantiated by the fact that unshaded plants have often lower ash contents than shaded plants (Blackman and Rutter, 1949) and may show visible symptoms of deficiency. Consequently, due to the unbalanced metabolism of the plant, the yield (growth) will decrease, probably both directly and indirectly as the result of increased fall of deficient leaves.

The removal of shade from previously shaded plants has been found to lead to marked increases in yield, yield increases which were the greater as shade had been the denser. Apparently, the plants are then able to make use of mineral reserves available in the soil or in the plant.

It is evident from the complexity of the relation between shade and nutrient supply as discussed in the foregoing that the old fashioned "shade-loving plant" concept is not valid. Extensive investigations carried out by Blackman and coworkers have more than substantiated this. They found that the net assimilation

rate (rate of dry weight production per unit area) of the great majority of plant species investigated—among which were some with shady habitats—was limited by light, while reduced light always reduced the relative growth rate (Blackman & Black, 1959). Both Barua (1957) and ourselves (Visser, 1960, 1961b) found likewise with young tea plants that the net assimilation rate (and also growth when the nutrient supply was ample) increased with increasing light intensity.

Observations of Blackman and Wilson (1951a) as well as those earlier published by Blackman *et al* show clearly that plant species cannot be simply divided into "sun-loving" and "shade-loving" plants, merely because of their association with open or shaded habitats, but that much more specific criteria (as outlined by Blackman & Wilson, 1951b) are required.

In this context the conclusions reached by Blackman and Rutter (1950) from their studies on the so-called typical shade plant, bluebell, are of interest. "In woodlands, shade *per se* can only be regarded as an inimical factor; the prevalence of bluebell in deciduous woods is attributed to the absence of agressively competetive species and more particularly to the protection provided by such habitats against grazing animals. Finally it is advanced that precisely the same factors operate in confining other species to woodland". We suggest that the tea bush found its habitat in forests for the same reasons. Apart from differences in soil fertility between forest and grass lands, the fire hazard in grass lands alone would have kept the tea out of it, while possibly also climatic differences may have an influence.

Experiments have not revealed any evidence that tea particularly likes shade; on the contrary there is ample justification for defining it as a "sun-loving plant".

## 7. Summary and conclusions

1. The experiments reviewed above show that responses to changes in fertilizer rates are less under shade than they are in full daylight. This has two aspects: (*a*) when shade is present, reduction in fertilizer rates has less detrimental effect on yield; and (*b*) when shade is absent, increase in fertilizer rates has more beneficial effect on yield. That is to say, if soil fertility and fertilizer applications are low, the shaded plant will tend to yield more; but with good soil and ample fertilizer, the unshaded plant will tend to yield more.

2. In a rough sort of way, shade can be said to be equivalent to a certain amount of fertilizer; the nitrogen-equivalent of shade may vary between 20 and 80 lb per acre. In general, the shade effect in terms of its equivalence to nitrogen (and other elements) will depend on both the shade density and the soil fertility. When the nitrogen availability (application) is low, nitrogen fixed by leguminous shade trees may also play a part. It would appear that nitrogen is the primary limiting factor for the growth and yield of unshaded plants; other nutrients, such as potash and phosphate, may become limiting as well, but probably only when nitrogen requirements are fulfilled.

3. With heavy shade or high soil fertility, it is to be expected that yield will become subject to diminishing returns much sooner, (*i.e.* at lower additional fertilizer rates) than when the shade is thin or the soil fertility is low; under good soil conditions, shaded tea may respond little to nitrogen because it is light and not nitrogen that it lacks, while at low soil fertility, responses of shaded tea may be linear up to a relatively high nitrogen level.

4. With poor soil conditions and a poor stand of tea, it is probable that the fertilizer application required to obtain comparable yields from unshaded tea would already be so high as to make any further increases in manuring uneconomic. Under such circumstances the presence of a good stand of shade trees is desirable, if not essential, from both agricultural and economic points of view. The same is true when a policy of moderate or low manuring is or has been adopted. Whereas without shade the yield would drop and the bushes deteriorate, with shade a moderate yield can be maintained. Probably the best and most economic way of improving poor tea fields that are lacking in shade and soil cover would be to re-establish or increase the shade.

5. It would be more profitable to remove the shade trees from good tea fields than from poor ones, as considerably less nitrogen would be required to obtain worth-while yield returns. In good fields the function of shade trees as providers of organic material is also less important than in fields with an inadequate cover. It must be noted that the yield response to shade removal is directly proportional to the original shade density, so that no great increases must be expected if the field was only thinly interplanted or the shade trees were frequently and severely lopped.

6. Disappointing results in the recent past, when on many estates shade trees were removed because of Blister Blight, were almost certainly due to the fact that manuring rates were low and by no means sufficient to meet the increased nutrient requirements of the unshaded tea. The logical consequence was that after the tea had exhausted available reserves, its yield decreased. There are good reasons to believe that the yield increase can be largely maintained if manuring rates are stepped up simultaneously.

7. There are indications that the characteristics of the tea—particularly leaf size, dry weight, ash content and quality—are to a greater or lesser extent influenced by the prevailing light intensity. However, the magnitude of the variations with light will probably be small if fertilizer applications are adequate. It is not known whether or not nitrogen application (with proportional amounts of P and K) exceeding 100 lb. per acre will affect quality.

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# DEVELOPMENTS IN THE CONTROL OF THE MEADOW NEMATODE

M. T. Hutchinson

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Although a number of other nematodes have been found in or around the roots of tea, the root-lesion or "meadow" nematode has long been recognized as the most important species. This nematode at first was known by the rather complicated name of *Anguillulina pratensis* de Man. In succeeding years, its name changed to *Pratylenchus pratensis* de Man and then to *Pratylenchus coffeae* Zimmermann. It is now known as *Pratylenchus loosi* Loof—both in recognition of the fact that as a species it differs from *Pratylenchus coffeae*, and as a tribute to the work of Mr Clive Loos whom most of you will recall as one of my predecessors at the Institute.

Now, what is a nematode? I dare say that most of you have never seen one, and that perhaps half of my audience does not even believe in them! Although nematodes can be viewed to best advantage in a living state and through a low-power microscope, some idea of their size and shape may be gained through photographs.

Plate 1 shows an adult female of the meadow nematode in comparison with a human hair. Although it is visible to the unaided eye, its light colour makes it difficult to see unless a microscope is used.

The head end of the meadow nematode is also shown in Plate 1, and is typical of plant parasitic nematodes. A hollow stylet, very much resembling a hypodermic needle, can be thrust from the mouth opening into a plant root. This stylet is connected with a strong, muscular pumping apparatus that allows the nematode to withdraw the liquid contents of plant cells as food. The digestive fluids that the nematode pours into the cells through this stylet, and the bacteria and fungi that can enter the openings made by the stylet, are the principal reasons for injury to plant roots. In addition, a number of nematodes actually enter the roots and make their way through the plant tissue, carrying bacteria and other organisms with them. The meadow nematode is one of these.

Injury caused to tea by the meadow nematode (Plate 2) can easily be confused with that caused by other conditions or pests that prevent uptake of water and fertilizers into the leaves. Such conditions include insufficient manuring, underlying slab rock, or water-logged soil. Pests that also produce similar effects include *Poria* fungus, and the Shot-hole Borer. The meadow nematode gradually destroys the root system of the tea plant, by attack on both the feeder roots and the large storage roots. Under conditions otherwise favourable to growth, infested tea may show no sign of injury. However, if the bushes are exposed to other adverse conditions, such as prolonged dry weather, the leaves turn yellow and defoliation occurs.

Plate 2 also shows a storage root of tea from which the outer bark has been scraped to reveal the dark area or "lesion" in the cortex where several hundred meadow nematodes are feeding. Such lesions can eventually expand to girdle large roots and thereby kill the portions beyond the lesion.

This meadow nematode causes losses to Ceylon tea that are not precisely known, but must involve several million rupees per annum. Our programme for control of this pest can be outlined under four headings: 1. study of its distribution; 2. protection of plants in the nursery; 3. recovery of infested tea in the field; 4. selection and testing of clones for replanting that are either resistant to or tolerant of the nematode.

A study of the distribution of the meadow nematode is important in determining whether or not low-country and mid-country estates need to be concerned with using resistant or tolerant clones for replanting, and also whether or not meadow nematode can be blamed for weak tea in these areas. In our laboratory we have a map of the planting districts of Ceylon, whereon are marked all estates from which soil samples have been received over the past 18 years. Dark pins indicate estates where meadow nematode has either not been found, or where it has been found in only small numbers. Light coloured pins indicate estates where large numbers of the meadow nematode have been found. In most cases, these are associated with obvious injury to the tea. From this map, it appears that large numbers of the nematode have usually been found only on estates above 4,000 ft. elevation. However, we are testing this by setting out infested plants in jungle areas at 8 elevations from near sea-level to above 7,000 ft. The plants will be examined at intervals to determine whether or not the nematodes fail to maintain themselves at lower elevations. If this experiment shows that the meadow nematode cannot survive in numbers in the low-country or mid-country, these areas will not need to be concerned about its control.

The second part of our programme is concerned with keeping meadow nematodes out of tea nurseries, since infested nursery plants are the best means for spreading the nematode around an estate. Fumigation of the striking beds before setting out cuttings, and of soil to be used for basketing, has already been shown to be a necessary and effective practice. However, no method has been demonstrated for ridding nursery plants of the nematode once they have become infested. As the result of an experiment wherein various pesticides were drenched into infested nursery beds, we have *preliminary* evidence, however, that the nematode can be completely eliminated without harm to the plants, and that the plants will recover normal growth. Further experiments are in progress.

The third part of our programme is concerned with measures to reduce the number of meadow nematodes in mature tea. For this, we are testing the effect of adding large amounts of composted cattle manure, and the effect of inter-planting marigolds with tea after pruning.

In theory, the addition of compost could either reduce the numbers of meadow nematodes by multiplying their enemies, or increase their numbers by producing a large number of new roots for them to feed upon. It may seem strange that compost might multiply the enemies of the meadow nematode, and therefore an explanation may be in order. There are basically three different types of nematodes in the soil: those that feed on bacteria and possibly directly on organic matter; those that feed on other nematodes; and those that feed on plant roots. Addition of compost should increase the number of those nematodes feeding on bacteria or organic matter. An increase in these so-called saprophagous nematodes should provide more food for the predaceous types feeding on other nematodes. These in turn, should also feed upon the plant parasitic nematodes. Unfortunately, we have not yet demonstrated these last two possibilities. With an application of 20 tons of compost raked over ground that had just been deep forked, we found a rapid but temporary increase in the numbers of those nematodes feeding on bacteria or organic matter. There was, however, no accompanying increase in predaceous nematodes, or decrease in the meadow nematode.

Plate 1. *The root-lesion or Meadow Nematode, Pratylenchus loosi*
Head end much enlarged, showing the hollow stylet with which the nematode punctures plant roots.

Adult female, alongside a human hair. A smaller, saprophagous nematode is seen at the left.

Plate 2. *Injury to tea caused by P. loosi.*
Dark lesion in cortex of storage

Defoliation of mature bush.

Plate 3. *Susceptible clone TRI* 2120, showing effect of 5 years' infestation with *P. loosi.*

Compared with uninfested controls.

Plate 4. *Tolerant clone Kirkoswald* 145, showing effect of 5 years' infestation with *P. loosi*

Compared with uninfested controls.

Plate 5. *Resistant clone Drayton* 95, showing effect of 5 years' infestation with *P. loosi*

Compared with uninfested controls.

Interplanting marigold in mature tea after pruning is probably a more practical measure for most planters, since there seems to be an almost unlimited supply of marigold seed available, compared with a very limited supply of cattle manure. In spot checks on four estates, we have found that tea with marigold has less meadow nematode than adjacent tea without marigold. These results, as well as those obtained previously by Dr Visser, have encouraged us to go forward with an expanded programme on marigold, both in the field and in the laboratory.

Both compost and marigolds appear to produce a definite improvement in the growth of tea and, in the case of marigold, we are planning yield trials to estimate this improvement more accurately.

The final part of our programme is concerned with testing and further selection of clones that are either resistant to or tolerant of the meadow nematode, for use in replanting.

The tests of clones in pots, begun by Mr Loos and continued by Dr Visser, has just been concluded. It has revealed three basic types of clones: susceptible, tolerant, and resistant.

Plate 3 shows plants of the susceptible clone TRI 2120. These plants in common with all others in the pot tests have been pruned three times during five years. Note that growth of the infested plants has been retarded by the nematodes in comparison with the uninfested plants.

Shown in Plate 4 are infested and uninfested plants of clone Kirkoswald 145. The infested plants have made good growth even though the nematodes are present in large numbers. Therefore we say that this clone is tolerant.

Plate 5 shows infested and uninfested plants of clone Drayton 95. The infested plants have made just as good growth as the healthy plants, but the reason is that the nematodes have not been able to increase in numbers. Therefore we say that such a clone is resistant.

Only one source of the meadow nematode was used for these experiments. But we have evidence that populations of meadow nematodes from different sources will affect a given clone differently, so we are now testing our most resistant clones against populations from 25 different estates. The results of this test will help us to select those clones most likely to do well on *any* infested estate. In the meantime, we are setting out plants of clones that so far appear to be resistant or tolerant, to provide an adequate number of cuttings for replanting infested areas.

A further part of this programme is concerned with making new selections from estates. We have in mind about 30 such selections, which will be tested against 25 populations of the nematode for resistance. A rapid method should enable testing of all these clones within 18 months.

A final part of this programme is concerned with the reasons why clones are resistant. We have already found that clones TRI 2135 and Drayton 95 can resist the entry of certain populations of the meadow nematode. Other possibilities for resistance include clones that can prevent maturity or normal fertility of the nematodes.

To review, the four approaches being made for control of the meadow nematode in tea are concerned with: 1. determining distribution; 2. elimination in the roots of nursery plants; 3. lowering numbers in the roots of mature tea; and 4. selection and evaluation of clones that are resistant or tolerant. There are good reasons to be hopeful for success in all these departments.

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**Question No. 68.**—Anon.

Do you advise lopping marigolds or allowing them to flower, with particular reference to possible competition with the tea in dry weather?

*Dr Hutchinson:* This question concerns the lopping of marigolds to protect the tea from competition during dry weather. In the absence of exact knowledge we would say: Yes, lop the marigolds at about two feet high. If you lop them much lower, re-growth will be poor. But there is also the question of the stage of marigold growth at which it exerts its effect on the eelworm. We are currently experimenting with this. It may be that it needs to mature in order to produce its greatest effect on the eelworm. Further, some people might want the marigold to mature in order to obtain seed. But remember that once it has flowered and seeded, then there is no point in lopping it, because it will not then re-grow. Lopping must be done before any extensive flowering has occurred, if you are to get additional growth.

**Question No. 69.**—Anon.

Is it better to use organic or inorganic manures on tea suffering from Meadow Eelworm?

*Dr Hutchinson:* If we are thinking in terms of blood meal as the organic manure, provided they have the same analysis as an inorganic manure, there is very little to choose between them, because the amount of "Sterameal" would not be great enough to contribute any real addition of organic matter to the soil. If we are thinking of compost in addition to inorganic manures, then many planters believe that it helps. We are hoping to obtain specific yield records on this matter, so that we will not have to rely on what may well be correct results but which at present lack adequate figures. Speaking about the question of manuring and eelworm, it has been found in the United States and elsewhere that increasing the potash manuring of perennial trees does increase their tolerance to meadow eelworms, and we are contemplating an experiment along these lines.

# RESPONSES TO MANURING IN VARIOUS LOW-COUNTRY CONDITIONS

A. W. R. Joachim

## Introduction

The yield of tea under estate conditions will depend on a number of factors, *e.g.* the yield potential of the seed and jât of tea grown, the density of planting, the amount and distribution of rainfall, the system of pruning, the method of plucking and manuring, the incidence of pests and diseases, *etc.* The optimum response to some of these factors is dependent on others; for example, manuring will give the best results if the rainfall is adequate and well distributed, if there is a sufficient stand of bushes to utilise the manure applied, if the bushes are pruned in the proper way, and if pests or diseases do not upset the normal functioning of the bushes. In short, yield is the integrated effect of a number of factors operating together, any one of which may become the limiting factor in any one year. Hence, even on the best-managed estates, where the general trend of yields over a period is rising, there can be an occasional shortfall of crop.

In order to investigate the effect of one of the major agronomic factors on tea yields, namely manuring, which has contributed greatly to the phenomenal increase of the low-country average during the past five years, typical estates in each of the planting districts of the zone were asked for information on the acreages cultivated, manurial applications given, yields obtained and rainfall conditions during the past 12 years. In all, 31 estates were addressed and I am very grateful to the 26 estates who have furnished some or all of the information requested. I now propose briefly to survey the main conclusions derived from the statistical examination of the data and to relate these to the findings from our own limited experimental work.

## Survey Facts

The estates covered in this survey were at elevations ranging from 200 to 2,000 feet, and had annual rainfalls varying from 50 to 230 inches. The low rainfall-averages occur in the Balangoda area, which experiences severe droughts and wind in the South-West monsoon; and the high rainfalls occur in the Kelani Valley and parts of the Ratnapura district. The pruning cycle is of two years duration, but some estates adopt the 18th-month cycle, especially where Shot-hole Borer is a problem, and a few the 3-year cycle. The manure mixture used is mainly T. 521, which is the standard T. 500 with a higher proportion of potash, and variants thereof. In earlier years, potash levels, in accordance with the views held then, were appreciably lower than in recent times. The amounts of nitrogen applied over the period varied from 45 to 150 lb. per acre per annum generally, but for the past 8 years or so, rarely has the annual application fallen below 80 lb. per acre. Magnesium in the form of dolomite has been sporadically used on some estates, but one estate has systematically incorporated magnesium sulphate in its standard mixture for the past 5 years.

## Statistical Terminology

Before discussing the results of the examination of the data, I should like to explain briefly a few statistical terms which will be referred to in the course of my paper. The term *correlation coefficient* is used to denote the degree of association between two variables, *e.g.*, yield and nitrogen. This coefficient varies between plus 1 and minus 1; a positive value indicates that an increase in one factor is associated with an increase in the other, while a negative value indicates that when one factor increases the other tends to decrease. A statistic calculated from the correlation coefficient and termed the *predictability* or *precision index* measures the precise contribution of any one of a number of factors to the whole result. It is appreciably lower than the correlation coefficient. The *regression coefficient* measures the rate of increase or decrease of one variable per unit increase of the other. The relationship between the two is expressed as a simple linear equation: $y = a + bx$, where $a$ is a constant, $b$ the regression coefficient, $x$ the independent variable, and $y$ the dependent variable. These statistics are illustrated in Fig. 1 (p. 137) where $y$ is the yield of tea per acre, $x$ the amount of nitrogen applied in the fertiliser mixture, $b$ the regression coefficient, and $a$ the constant.

A *multiple regression* equation is one expressing the relationship between three or more variables *e.g.* yield, nitrogen and rainfall. The term *partial correlation* is used to indicate the correlation between two variables when the third is held constant. It is derived from the total correlations between the factors.

## Rainfall and Yield

Now to the results. In the low-country, rainfall is generally not a limiting factor of yield, the exceptions being the Balangoda district and parts of the Matara and Kegalle districts. In these and particularly in the first, it is the incidence of the rainfall in certain months, and not the total rainfall, that matters. But when the total rainfall in any one year falls appreciably below the normal, the yield is adversely affected. It is possible to calculate a multiple regression equation between rainfall (R), manuring (N), and yield (Y), which will fit in well with the data. Such an equation calculated for an estate in the Matara district was as follows: $y = 415 + 2.1\,N + 2.64\,R$. The application of this formula in years of deficient rainfall will give an indication of what yield can be expected. A statistical examination of the rainfall figures during critical periods of the year and of the yield data should result in higher correlations being obtained, and regression equations which give closer agreement between observed and calculated yields.

## Manuring and Yield

A study of the yield responses to manuring has been made on data from 22 estates which supplied adequate information. The typical patterns of such responses are shown in Fig. 2 (p. 138) where yields are plotted against the nitrogen in the fertilizer mixture applied.

The regression lines show the varying trends of yields on different estates. In nearly all cases the response to manuring over the basal level is positively significant, but in one case the crop showed no significant change when over 60 lb. of nitrogen per acre was given. In the other cases the magnitude of the regression coefficient or the rate of increase of yield per unit of nitrogen, within the limits applied, varies greatly, *viz.*, from 0.8 to 9 lb. of crop per pound of nitrogen applied in the mixtures used. On estates which are high-yielding, the regression coefficient

may be high and the constant low *or* the regression coefficient may be low and the constant high. On low-yielding estates the regression coefficient is low and the constant also relatively low. Obviously, the greatest economic advantage from manuring is obtained on those estates where a high regression coefficient is noted. A low regression would indicate the operation of a limiting factor of yield. Whether this is inherent in the climate, as in the Balangoda area, or whether it is a soil factor or the tea is too old or of a jât which shows a low response to manuring under shade, or whether the stand of tea is inadequate for the manure applied, or pests and diseases limit yields, can only be ascertained after further inquiry and experiment. That pests and diseases have affected yields in some years has been indicated by some estates.

In regard to bush stand, it is clear from the literature (Visser *et al*, 1958) that planting distances do affect yield appreciably. It is not uncommon in the low country for young-tea areas which have a stand of about 6,000 bushes to the acre to yield over 2,000 lb. when about 10 years of age, when the old fields give less than 1,000 lb. per acre. It is doubtful if the old tea in the greater part of the low country has an average stand of more than 2,500 bushes per acre. Fig. 3 (p. 139) shows how yield can be affected by bush number; the data are from our manurial trial at Endane over the past five years, where applications of nitrogen higher than the basal dressing of 80 lb. per acre per annum have not increased yields. The correlation coefficient between these two factors was found for the first cycle to be 0.74, with a precision index of 0.33. In simple terms, about one-third of the variability of yield of the plots is, in this instance, determined by bush number.

The statistical examination of the data shows that yield, in nearly all cases where a significant response has been obtained, is closely related to the quantity of nitrogen applied. The increase is linear up to about 145 lb. per acre, after which there is generally a tendency for yields to level off. In this connection, reference may be made to Eden (1958) where he indicates from experiments carried out in Assam and Nyasaland on the use of high levels of nitrogen, that in practice the law of diminishing returns begins to operate at levels of nitrogen greater than about 200 lb. per acre, though the theoretical dosage is about 240 lb. per acre. The yields obtained were in the region of 1,700 to 1,800 lb. per acre. Experience in the low country of Ceylon is different; yields over 2,400 lb. per acre have been obtained with dressings of less than 150 lb. per acre of nitrogen.

With regard to potash, it has been difficult to assess the effect of this nutrient on yield independent of nitrogen, as there has been a fair degree of consistency in the use of standard mixtures with constant ratios of N, P and K on most estates and thus inadequate random variation of the data. In the relatively few cases where there has been some variation in the potash/nitrogen ratio, the partial regression coefficients and partial correlations calculated between potash and yield when nitrogen is kept constant, appear to indicate that in these instances the use of potash in higher than standard amounts has not been of advantage. It is notable, for instance, that in our Endane manurial trial, potash applied in excess of the basal level of 60 lb. per acre per annum has not increased yields over the average of 1,600 lb. per acre. This statement should not, however, be considered to be generally applicable in the low country since potash deficiency does exist on some estates in the zone.

With regard to magnesium, the results obtained on an estate in the Kelani Valley where crude Epsom salts was used with the standard mixture at the rate of 2 cwt. per acre per annum over a period of five years, reveal a significant average increase in yield of 235 lb. per acre per annum during this period over that of the previous five years when magnesium was not used. This increase is not due to the slightly higher doses of nitrogen given in the later period, but it is due partly to the

increasing acreages of new tea coming into bearing during the period. Statistical analyses show that there is generally a high positive correlation between yield and the acreages of new tea coming into bearing. There is, however, little doubt that on the estate in question magnesium applied as sulphate has contributed to the increased yield obtained since 1955. As regards the effect of dolomite, the data are insufficient to estimate its precise effect on yield, but there are indications of a beneficial effect where the treatment has been carried out systematically.

As regards manuring in general, there is evidence in a number of instances that where, for say reasons of economy, the amounts of fertilizer on a normally well-manured estate, with an average stand of green-manure trees, was reduced in quantity in any year, the yield did not fall appreciably in that year provided other factors, *e.g.*, rainfall, were satisfactory. In some cases where the yield trend was rising, *e.g.*, in young tea, the yield even increased. A case in point is shown below from an estate in the Morawak Korale.

TABLE 1.—*Reduction of manuring and yield*

(Area of field 20 acres—planted 1948/49)

| YEAR | NITROGEN lb. per acre | YIELD lb. per acre |
|---|---|---|
| 1955–56 | 125 | 1,454 |
| 1956–57 | 112 | 1,104 Pruning year |
| 1957–58 | 111 | 1,182 |
| 1958–59 | 46 | 1,421 Pruning year |
| 1959–60 | 200 | 2,398 |

## Conclusion

In conclusion, I have to express the hope that this article will serve the purpose, if nothing else, of showing that if accurate data on yields in relation to manuring are maintained on estates over a sufficiently long period and the data are statistically examined from time to time, valuable information can be obtained on yield trends, and the effectiveness or otherwise of any particular treatment and its economic implications. The advantages of keeping such records are, therefore, obvious.

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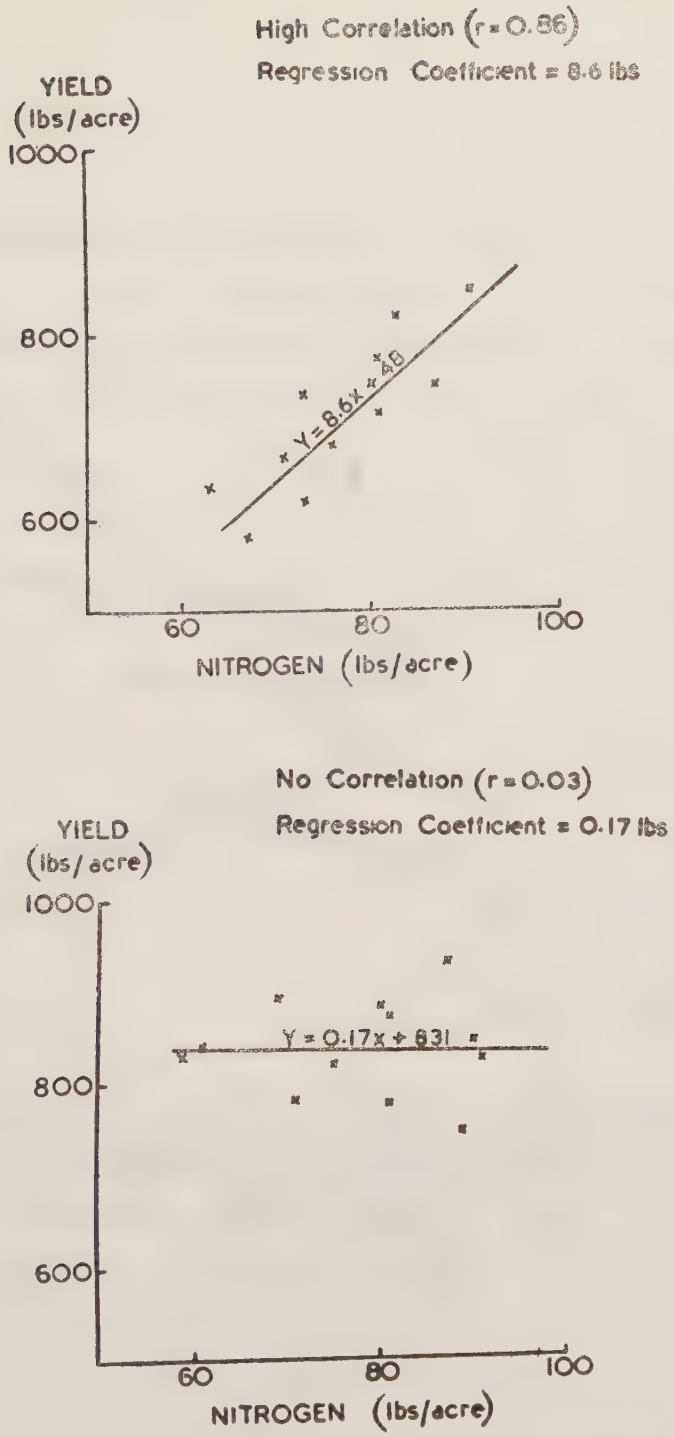


Fig. 1. The relationship between yield (y) and nitrogenous manure (x) in two instances.

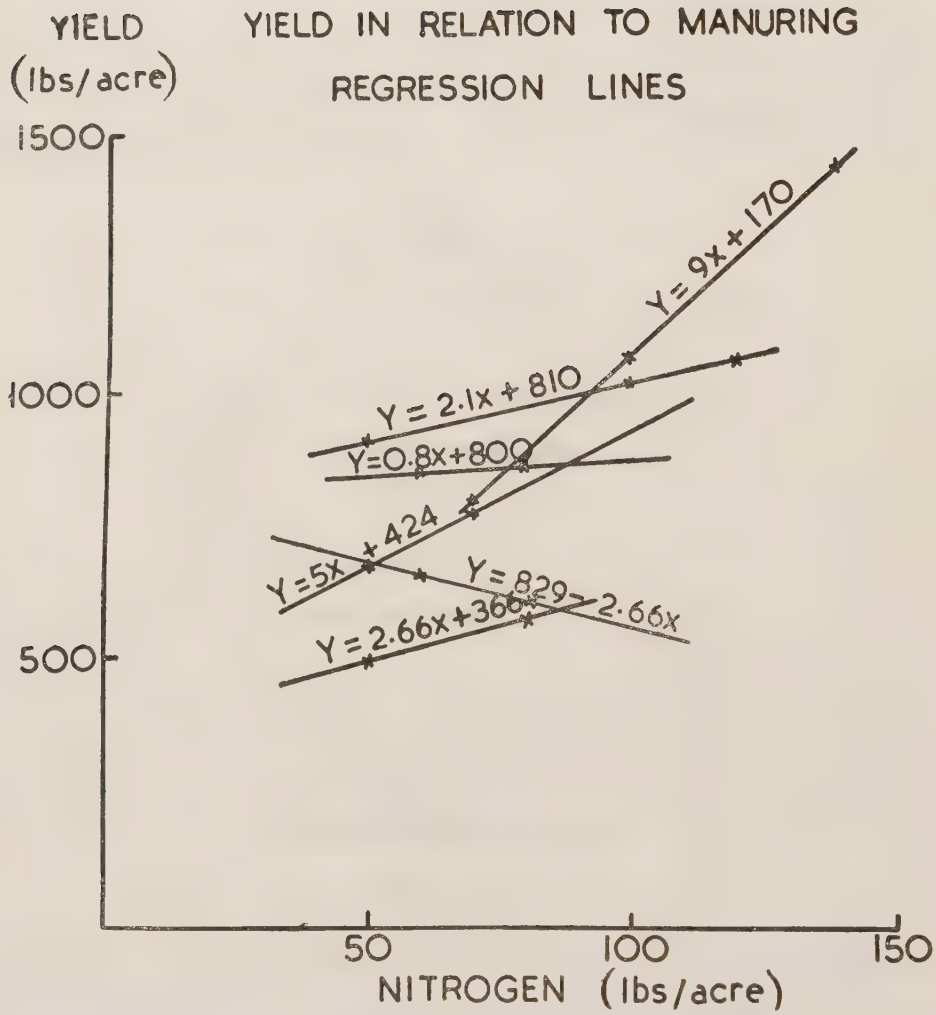


Fig. 2. The response in yield to manuring (nitrogen) on six different estates, shown as regression lines.

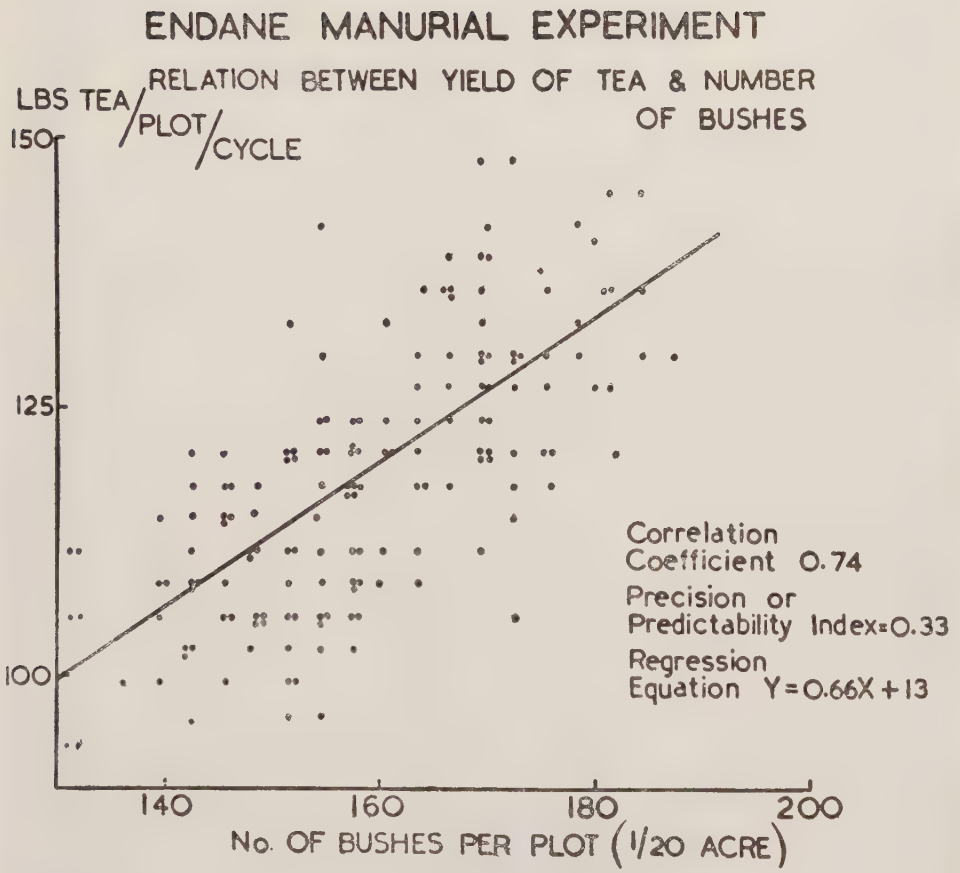


Fig. 3. The effect of bush density on yield.

# ORGANIC MATTER AND PARASITIC FUNGI

D. Mulder

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When a disease or a parasite has established itself in a particular host, why does it not always increase until it eventually kills or smothers the host? On the one hand, the host often resists the disease with increasing force; and on the other, even parasites have their enemies. Even parasites have to struggle for their existence and the fact that they occur at all means that they have achieved some success in this struggle.

In Ceylon, it seems that Blister Blight has found a situation in which it can be more successful than in Assam. Such a situation is not uncommon for organisms that attack plants, when those plants are grown in new areas, where they have never occurred naturally. The conditions in the new areas may be unfavourable in some respects to particular plant species either in climate or in disease, unless the plants are helped by man. With extensive areas planted in one species—mono-cropping—the danger is increased of the balance between crop and environment breaking down, resulting in an epidemic. The help required from man to restore and maintain the balance may be great or small. It may often be most economical when man can enlist on his side the help of other organisms, as in the well known case of *Macrocentrus* parasitising Tea Tortrix.

There are various ways in which organisms can keep each other in check. Straight-forward swallowing occurs between animals and is the habit of eelworms, but amongst fungi and bacteria other more insidious ways of hindering each other's development prevail. Their action, known as antagonism, consists of the secretion of an organic chemical compound which hinders other organisms in their growth or even kills them. The modern pharmaceutical industry is partly dependent on these products; penicillin is one of them, and streptomycin another one. Their group name is antibiotics.

Although we cannot yet make much use of these compounds in the control of parasitic fungi on plants, we can indirectly profit from their production on the spot, by saprophytes in the soil. Some fungi combine an antagonistic action on their victims with a subsequent parasitic action. Others are only antagonistic. The antibiotics secreted by soil saprophytes affect not only other fungi in the soil but also parasitic fungi living on various parts of the plants growing on that soil. It has been found that several antibiotics are absorbed by the plant roots and, being transported throughout the plant, cause immunity to either bacterial or fungus diseases.

Antibiotics are mainly produced by fungi, actinomycetes, and bacteria. A great number of antibiotics are produced by actinomycetes. This group of primitive fungi consists mainly of saprophytes living on decaying organic matter in the soil. In plant-disease control, antibiotics derived from soil organisms have been used as sprays, dusts, dips, for injection into the plant, and for soil application.

I have to limit myself here to the last mentioned method of soil application in order to reach my ultimate aim—that is the control of Red Root Rot caused by

Plate 1. Left—Part of the root of a tea bush infected with *Poria hypolateritia*, dug up from an unfumigated plot and kept in a moist chamber. Note the abundant growth of white strands of *Poria* mycelium.

Right—Part of a root previously infected with *Poria* from a plot fumigated with D-D mixture and kept in a moist chamber. It shows the abundant growth of the mycelium of *Trichoderma viride*.

*Poria hypolateritia*. Although theoretically a direct soil application might be preferable, the trouble is that many of the antibiotics are also extremely costly to buy and are readily decomposed or otherwise inactivated in soil. Gliotoxin, for instance, produced by a soil fungus called *Trichoderma viride*, is decomposed in soil a few hours after application. This fungus is very common in tea soils in Ceylon, but depends on organic matter for its growth.

In view of this situation, we have not tried to apply any antibiotic to the soil in order to control *Poria*, but we have started to study the behaviour of *Poria* and *Trichoderma* when we bring them together on an artificial food base and in soil.

When we had got as far as that, an estate nearby was so alarmed by the costs of *Poria* eradication that it was looking for a cheaper method than sifting the soil. They asked for our opinion when they started to disinfect soil by D-D fumigation against *Poria* and it was then that a very happy co-operation developed on this subject. Both approaches finally came together in one working hypothesis based on the antibiotic action of this saprophytic fungus, *Trichoderma viride*. It had been proved earlier that *Trichoderma* can parasitise and antagonise a number of parasitic soil fungi among which are *Rhizoctonia solani*, *Armillaria mellea* and *Fomes lignosus*. It has also been shown that parasitic soil fungi are much more sensitive to D-D fumigation than is *Trichoderma*. What is left of living mycelium of a parasitic soil fungus, after this partial soil sterilisation, can then be finished off by both antagonistic and parasitic action of *Trichoderma* (*see* Plate 1).

So far we have been able to show that antagonistic action of *Trichoderma* on *Poria* does indeed exist. We have *not* observed any *parasitic* action but this might depend on the strain of fungus we have used.

Naturally we cannot yet say whether D-D fumigation or any other partial soil sterilisation will have a future as a *Poria* eradication measure because the experiments have not lasted long enough. *Poria* might survive the treatment in deeper soil layers or under the bark of bigger roots. Successive planting of the experimental area with *Tephrosia* and tea will show us whether the treatment is reliable. For the moment our results are a nice illustration of the hidden capacity of the soil itself to deal with parasitic fungi. This capacity can come out in the open if we help the micro-flora to develop in a favourable direction by drastically changing its composition by partial sterilisation of the soil. The role of organic matter in this process is of the highest importance as it serves as a food base for the harmless and even beneficial saprophytic soil fungi.

I would like to end my talk by citing one of the foremost specialists on the subject of antibiotics, Dr P. W. Brian, who summarised the problem in 1956 as follows:—"The idea I want to leave in your minds is this: that root disease is not just a private affair of host plant and parasite, but that the rich saprophytic microflora of soil and plant surface is also intimately involved."

**Question.**—Superintendent, Meddecombra North.

Does Dr Mulder recommend the digging of an isolation trench or drain round a treated patch of *Poria*? Or is it considered that a ring of *Tephrosia vogelii* is preferable?

*Dr Mulder:* The trench has been omitted from the recommendations because it has been shown that a trench of two feet is not an absolute barrier to *Poria* (Reference: Gadd, C. H., *Monogr. Tea Prod. Ceylon* no. 2, p. 38). The area is forked and cleared of roots to a depth of three feet and all roots you find going to

lower depths are followed up and cleared out. Only if you want to leave the area for some time after pulling out the bushes, then it might be good, to fill up the time lag between the pulling-out of the bushes and forking, to isolate the whole area with a trench of three feet depth; although the value of it is doubtful.

As to the value of an indicator plant, if you are not fully convinced that your *Poria* gang has done a very thorough job, then it is certainly a good thing to plant *Tephrosia* at least along the border between healthy tea and the patch, because it will show what kind of job has been done, and it is better to know that before you plant the new tea.

**Question.**—Mr K. D. Seelanatha, Matale West Estate.

It has been found that generally the micro-life in the rhizosphere is beneficial and even essential to the plant, like saprophytic fungi, mycorhiza, nitrifying bacteria, predators etc. Isn't soil sterilisation bound to eliminate this useful micro-life, resulting ultimately in lowering the uptake of nutrients and consequent loss of yield?

*Dr Mulder:* The questioner is indeed right in assuming that many features of micro-life in the soil are beneficial to the plant. Total and enduring sterilisation of the soil would therefore be harmful to the roots; this is, however, difficult to achieve, and what we are envisaging is only partial sterilisation. Moreover, some time after this procedure, infection from all sides and by all kinds of organisms will occur, repairing the damage done to the microflora.

**Question.**—Mr C. B. Perera, Mahacoodagalla, Halgranoya.

I presume the digging of a trench is not favoured because roots from outside the isolated patch find their way into the patch below the level of the drain? Is it not possible to eliminate this by filling the trench and periodically cleaning it out, cutting off any roots that grow into the trench and filling the trench again with clean soil?

*Dr Mulder:* Trenching is not favoured for two reasons: (1) *Poria* rhizomorphs could possibly grow from the patch below the bottom of the trench to healthy tea outside; (2) roots of healthy tea could indeed grow below the trench, into the patch, and pick up *Poria*. Moreover a strong argument against trenching is that a trench decides on where the border of the *Poria* patch is. Anything happening outside the trench is no longer under control. If in this process of trenching a recently infected bush remains outside the trench then such a bush provides a further source of infection without being checked. If the trench is dug after uprooting two rows of healthy bushes then the whole procedure is not necessary at all, provided removal of all roots above pencil thickness to a depth of three feet is done immediately after clearing the patch. If, however, there is a time-lag between the latter process and the forking to three feet depth then a deep trench of three feet might be at least of some use. Digging a trench and filling it up again does not seem to be an economic proposition.

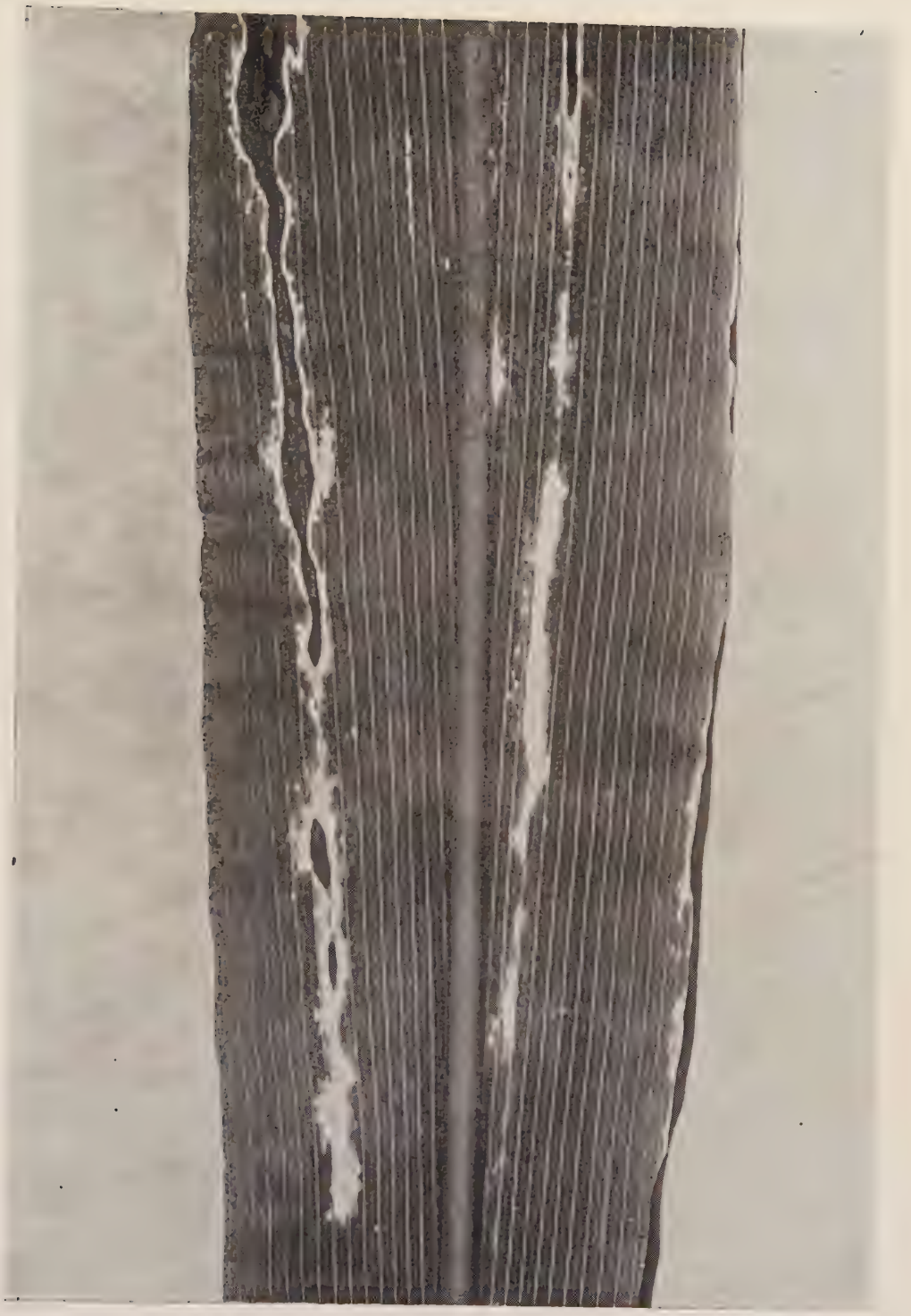

Plate 1. Bacterial leaf stripe disease of Guatemala grass (*Tripsacum laxum* Nash) Photograph taken with background light in order to increase contrast between green leaf, yellow diseased area and grey-black, necrotic area.

# A BACTERIAL DISEASE OF GUATEMALA GRASS

D. Mulder

## Introduction

During a preliminary study of mineral deficiency symptoms in Guatemala grass (*Tripsacum laxum* Nash) it seemed that certain longitudinal necrotic stripes in the leaves were not due to any known mineral deficiency or toxicity. Further work on these stripes revealed that this disease is due to a bacterium. It has been found at the Commonwealth Mycological Institute in England that the bacterium is a *Xanthomonas* species, but not identical with *Xanthomonas vasculorum* Cobb (Dowson), which causes a similar disease of sugar cane, called gumming disease.

## Symptoms

The first stripes are usually noticed at the tip. From the margin, yellow spots develop parallel to the main vein. Before the stripes turn yellow, a fading of the green colour can be noticed. After some time, a strip of leaf tissue starts to die from the tip of the leaf inward. The colour changes from yellow to grey. Long streaks of dead tissue develop which gradually extend in width, finally covering most of the leaf. Yellow spots may also develop at any other place on the leaf, though more rarely. Finally, dead streaks run along the whole length of the leaf.

So far no symptoms on other parts of the Guatemala grass plant have been found. In the case of the gumming disease of sugar cane, the main damage is done by the bacteria entering the stem.

## Causal Organism

When a small yellow part of the leaf is cut out and placed in water under the microscope the bacteria are seen oozing out of the vascular tissue. Although it has been possible to culture the bacterium on a nutrient substrate, no specific name can be attached to it at this stage.

## Occurrence

The disease occurs only when Guatemala grass is grown near tea or on tea land shortly after uprooting of old tea, or when Guatemala grass is manured for its own sake. It therefore seems likely that this bacterial disease is strongly linked with a rather high level of nitrogen nutrition or consequently a relatively low level of potash nutrition. Any Guatemala grass that shows the yellow colour of nitrogen deficiency is practically free from necrotic streaks.

The reason why nitrogen is brought in as the decisive factor is that it is well known that plants become more susceptible to various parasitic diseases with a higher level of nitrogen nutrition or a relatively low level of potash. Furthermore,

an edge effect is noticeable; plants along the edge of a field usually show better growth, due to the absence of food competition on one side. More luxuriously growing plants also show a more severe attack by this bacterial disease.

**Preventive Measure**

The link with the level of nitrogen nutrition provides us with a good preventive weapon against this disease.

Lowering of the quantity of nitrogen fertiliser in comparison with phosphate and potash is likely to create conditions under which the plant shows a higher resistance to this disease. At the moment it cannot be said at what level of nitrogen content the plant loses its resistance.

It is very likely that the lower potash content resulting from abundant nitrogen fertilising causes higher susceptibility to this disease. Therefore increasing the potash fertiliser should have a good effect.

**Warning**

Special attention should be given to the spread of the disease. Those Superintendents who wish to collect plants for planting out on recently cleared tea land should inspect the mother plants first for the presence of this disease. In case of a severe outbreak it is better to take the cuttings somewhere else, or if necessary wait for a dry spell of weather during which the attack abates and may even disappear. Transport of cuttings from one estate to the other should be avoided.

**Request**

For the purpose of collecting data on the occurrence of this disease, Superintendents are requested to inform the Pathologist, Tea Research Institute, if this disease is known to occur on the estate.

**Conclusion**

Guatemala grass has so far been free from any disease of major importance. The chances are, however, that under the present conditions of increased planting in connection with the replanting scheme, more important diseases will appear and spread in the developing monoculture. This bacterial disease may still be at a stage at which it can be held in check by a wise fertiliser policy based on the high potash requirements of this grass.

# DO NOT KILL YOUR MOTHER BUSHES

F. H. Kehl

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Leaves of plants contain an active pigment called chlorophyll that is able to absorb the rays of the sun and fix solar energy for manufacturing essential food material. This intake of energy may be compared in some ways to coal or electricity which give power to a factory.

Though the roots supply the plant with mineral salts, it is the leaves that provide the plant with carbon, an important constituent of plant tissues. Carbon dioxide which is present in the atmosphere is absorbed by the leaves in the presence of sunlight. It enters the cells of the leaves where chemical changes take place leading to the formation of carbohydrates (starch and sugar). This process of food manufacture is known as photosynthesis or carbon-assimilation.

The food made by the leaves is used for the development of new growth, *i.e.* new leaves and shoots, and any excess is stored for later use. For example, these reserves are used by a bush, after it has been pruned, for new growth. If the reserves are too little at the time of pruning, no recovery will take place and the bush will die.

Starch reserves can be assessed by examining roots of half-inch or more in diameter. The roots should be cut with a pair of secateurs or a sharp knife so as to expose a clean cross-section. This is treated with tincture of iodine. If adequate starch reserves are present, a deep blue colour will be produced; if no starch is present, only a yellow colour will appear.

In the low country and the mid-country, where physiological processes are much faster, excess carbohydrates produced are mainly directed to the production of new shoots. Consequently they do not have much chance of storing food reserves in the roots. Under such conditions a clean prune will not always be practicable, since a high percentage of bushes will fail to recover after the pruning operation. In these circumstances, it is essential that a sufficient number of leaves are retained on the pruned bush to provide the required supply of carbohydrates. This can be accomplished by suitable types of pruning such as rim-lung pre-prune or high cut-across pruning.

At higher elevations both growth and carbohydrate production are slower and a proportion of the excess carbohydrate produced is stored in the roots. It is, however, evident that the frequent removal of shoots from mother bushes, an operation that can be compared to a light prune, makes demands on what reserves remain available. It results in the reduction of carbohydrates available as reserve, owing to the frequent stimulus to the production of new shoots which are removed before they can have taken sufficient part in manufacture to compensate for the carbohydrates used. Accordingly, such bushes should not be given a clean prune but every effort should be made to leave sufficient foliage at the time of pruning, in order to manufacture all the carbohydrate required for recovery from pruning.

Beneficial results can be achieved by occasionally resting mother bushes, for about 3 to 6 months, until sufficient reserves are accumulated, before any type of pruning operation is carried out. It is however, essential to ensure that the mother bushes are adequately manured, if growth during the resting period is not to be limited on nutritional grounds.

The following is a suitable inorganic mixture for use with young plants.

| | *lb.* | *Nitrogen* | *Phosphate* | *Potash* | *Magnesium* |
|---|---|---|---|---|---|
| Ammonium sulphate | ... 100 | 20.6 | — | — | — |
| Saphosphosphate | ... 50 | — | 14.75 | — | — |
| Muriate of Potash (60%) | ... 25 | — | — | 15 | — |
| Magnesium sulphate (24%) | ... 25 | — | — | — | 6 |
| | 200 | 20.6 | 14.75 | 15 | 6 |
| | % | 10.3 | 7. 4 | 7.5 | 3 |

Alternatively a balanced organic mixture, containing 6½% nitrogen, 9% phosphoric acid, 9½% potash with magnesium sulphate added at the rate of 14 lb. to 100 lb. of the mixture may be used for the 1st year. The dosage of the organic mixture should however be about 50% higher than the inorganic mixture.

Four to six applications are made per year and the dosage adjusted to the age and growth of plants according to some such scheme as below:—

| *Years from planting* | *Approximate rate of inorganic mixture* |
|---|---|
| Up to 1 year | ½ to ¾ oz per plant per application |
| 1 to 2 years | ¾ to 1 ,, ,, ,, ,, ,, |
| 2 to 3 years | 1¼ to 1¾ ,, ,, ,, ,, ,, |
| 3 to 4 years | 1¾ to 2 ,, ,, ,, ,, ,, |
| 4 to 5 years | 2 to 2¼ ,, ,, ,, ,, ,, |

Where there is very vigorous growth, such as may be expected from clones like T.R.I. 2023, 2024, etc., then it may be advisable to increase either the dosage or the frequency of application.

It should be noted that the manurial requirements of clones at different stages of growth or under different conditions are not the same. Accordingly, until more information becomes available it will not be possible to lay down dosages with any degree of precision.

A mother bush from which cuttings are taken has to be pruned periodically. Like any pruned bush, the natural growth cycle starts with a vegetative phase and gradually passes over into a reproductive phase in which less leaf is produced, with shorter internodes, and a pre-ponderance of flower and fruit. Studies on fruit trees show that this change is accompanied by a change in the relative proportions of carbohydrate and nitrogen in the tissues of the plant; as the cycle progresses, the ratio carbohydrate/nitrogen increases. By supplying nitrogen to the mother bush, the time at which it ceases to put out foliage and produces flower buds instead can be delayed to some extent.

Whatever method of delaying the reproductive phase is attempted, inevitably the time comes when the vegetative phase decreases in activity. The mother bush is then pruned in order to deprive it of the potential flower buds which are laid down, long before they become evident. Cuttings taken off shoots in which the beginnings

of flower buds have already been formed do not root readily nor do they make vigorous growth. By pruning, the plant is once more forced into the vegetative phase.

The frequency of the pruning operation will depend on the elevation and the clone. At low elevations, and with a clone that has a tendency to flower early, pruning should be more frequently done than at higher elevations or with late-flowering clones. Generally, a mother bush from which cuttings are taken regularly should be given a pruning once in about every 15 or 20 months.

The time at which the mother bush should be pruned is important. Observations indicate that rapid growth is accompanied by a diminution of starch reserves since the production of new shoots can occur at a greater rate than the bush can manufacture material for their production. Where feasible, therefore, it is advisable, especially at low elevations, to prune before the period in which rapid growth is expected and pruning immediately after much active growth should be avoided.

If you keep on taking cuttings from a mother bush and then clean prune it, you may expect it to die. Give the bush a chance by resting it and by leaving foliage when you prune.

# MANURING MATURE TEA: THE NEW T. 700 SERIES; 1961

J. A. H. Tolhurst

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In 1955 the Institute published "A Guide to the Manuring of Ceylon Tea" (Lamb, Portsmouth and Tolhurst, 1955). This pamphlet was intended to be superseded whenever scientific research produced sufficient evidence to warrant a change. In 1961 we can safely say that the T. 500 series of manure mixtures will no longer satisfy the changing conditions which are resulting from ever-increasing levels of yield and of manuring. T. 500, therefore, is to be replaced by the T. 700 series in our present manurial recommendations for mature tea, and reasons will be given for suggesting the adoption of the new series of mixtures for low-yielding tea as well. Young tea manuring has its own problems and is dealt with in another paper (Tolhurst, 1961).

## NPK ratios in the T. 700 series

PHOSPHATE, $P_2O_5$ OR P.—When T. 500 was first brought into being, in 1952, it was felt that fixation of phosphate in insoluble forms might be a serious problem in some soils. As a measure of prudence, therefore, a proportion of saphosphosphate in the mixture was decided upon which provided more than twice the amount of $P_2O_5$ likely to be removed in crop and pruning wood. We have since learned that our tea soils are generally high in organic matter with correspondingly active microbial populations. It does not now seem that phosphate fixation can be serious under such conditions.

Long-term field trials, using soluble superphosphate in place of saphosphosphate, have offered some evidence that too high a rate per acre may even be detrimental to yield (Pearce, 1959).

Linked with this observation is the finding that tea is able to accumulate ample calcium from either superphosphate or saphosphosphate at quite low rates of use.

All these data have prompted us to reduce the proportion of saphosphosphate in the T. 700 series, to a level which is still above the likely replacement level for $P_2O_5$ in crop and pruning wood, but much lower than was provided in T. 500.

POTASH, $K_2O$, OR K.—Within recent years symptoms of potash deficiency have been noticed quite commonly, both on tea which has been highly manured with T. 500 or similar mixtures and on low-yielding tea with correspondingly low manuring levels. While the latter cases may be attributable to straight-forward undermanuring with potash, the occurrence of the deficiency on high-yielding tea may have a more complex origin (Tolhurst, 1961a, 1961b). Over-generous nitrogen application may be the main culprit.

Potash deficiency in high-yielding tea is apparently more probable at lower elevations, although the related symptoms of manganese toxicity are present on some highly-manured clones on St Coombs. It is the complexity of this particular

problem which leads us to offer three new mixtures varying solely in their potash content, with recommendations for selection in relation to climatic conditions and to yield level.

The future trend will doubtless be towards the richer potash mixtures. Any experimenting by individual estates in this respect would be encouraged, as, indeed, it would be in respect of other aspects of manuring. No hard and fast rule could ever be drawn up to cover all the varied conditions under which tea is grown.

**Nomenclature in the T. 700 Series**

It was found that the desired changes in phosphate could be represented perfectly well by the practical and euphonious basic formula—T. 700. Changes in potash content, the only further changes likely to be made, can thus be represented by a number such as 725, which shows at a glance that there is 25% additional potash in this mixture. There is no magic in the figures 700, etc., but there is great practical convenience.

The formulae are based on the three most commonly used fertilisers, but there is no reason why alternatives should not be used. For example, 50% muriate of potash, ammonium sulphate/nitrate (26% N), etc. Urea may be tried, with a warning that its effectiveness may be reduced, especially in very wet conditions. Nor, of course, do we wish to exclude compound inorganic manures with perhaps slightly different NPK ratios, or purely organic manures.

It is suggested that T. 700, etc. be retained as names, even if alternative components alter the formulae. The distinction could be made by quoting the percentage of nitrogen in brackets, *e.g.* where 50% muriate of potash is used, T. 700 would be re-written 'T. 700 (14.3% N)'.

T. 700

500 parts by weight—Sulphate of ammonia (20.6% N)
100 parts by weight—Saphosphosphate (27–28% $P_2O_5$)
100 parts by weight—60% muriate of potash.

At 14.71% N, 6.79 lb. contain 1 lb. N.

T. 700 is recommended as the basic mixture for up-country mature tea.

T. 725

The above formula is altered to read

125 parts by weight—60% muriate of potash.

At 14.20% N, 7.04 lb. contain 1 lb. N.

T. 725 is recommended as the basic mixture for mid- and low-country tea, probably for the drier parts of Uva, and probably for the highest-yielding tea up-country (see the paper on manuring young tea).

The above formulae are altered to read

150 parts by weight—60% muriate of potash.

At 13.73% N, 7.28 lb. contain 1 lb. N.

T. 750 is recommended for the highest-yielding tea at the lower elevations, and for tea which is known to show potash deficiency or severe manganese-toxicity symptoms.

**Rates of Application**

Low-yielding tea.—Tea which persistently gives low yields, say 600 lb. average or less, may be expected to have a less active root system to absorb manurial nutrients, particularly the soluble nitrogen and potash. Where economics permit, there is much to be said for manuring with the appropriate new mixture at a 12 lb. ratio (N to 100 lb. made tea). Where economics do not permit this, it is suggested that any saving on phosphate be used to increase the manure dose. A larger dose may also be expected to give better response by virtue of the fact that it could be distributed more evenly and more frequently, but the effects of changing dosages should be carefully analysed (*see* Dr Joachim's paper in this issue).

We have no record of phosphate-deficiency symptoms, recently identified as a very dark purplish discoloration on the mature foliage, in low-manured tea, but symptoms of nitrogen, potash, and magnesium deficiencies are common enough.

Tea in the middle ranges.—Experience suggests that a 10 lb. ratio of N per 100 lb. made tea is ample, under varied conditions, to support an increase in cropping capacity. Continuance of this level after the yield has obviously reached its maximum may do more harm than good. A reduction to the suggested maintenance ratio of 8 lb. N is then advised. With better distribution of manure it may be found that a lower maintenance ratio would suit some conditions; only by experiment on the estate itself could this be decided.

High-yielding tea.—Seedling tea which shows signs of passing the 1,200 or 1,500 lb. average appears to present special problems. T. 725 and T. 750 are recommended for high and lower elevations respectively, with possible experiment with even higher potash ratios. At the same time it is strongly suggested that the rate of manuring be kept as low as possible. Too high a rate of nitrogen per acre may nullify the effects of the increased potash, especially if sulphate of ammonia is used.

The efficiency of these root systems may be expected to be high, and an 8 lb. N ratio may in these circumstances be sufficient to allow expansion of cropping capacity, with a further reduction once the yield levels off at its maximum.

Details of rational methods of application of manure in relation to certain soil conditions have been given elsewhere (Tolhurst,1959).

**General**

Magnesium.—The above recommendations are given on the assumption that dolomite will be used as a routine manure, at the following rates:

| Average Annual yield of tea lb. per acre | Dolomite at a rate equivalent to: |
|---|---|
| Up to 750 | 70 |
| 750 to 1,200 | 100 |
| Over 1,200 | 130 |
| | lb. per acre/annum |

Details of application per cycle are given elsewhere (Tolhurst, 1959a). There is no reason to fear that dolomite would aggravate potash deficiency.

**Specific manurial recommendations**

This paper covers general manurial recommendations as far as we can judge them in 1961. For specific purposes, and for the furtherance of our knowledge, we shall doubtless issue advice or promote experiments which deviate from the above pattern.

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# MANURING YOUNG TEA: 1961

J. A. H. Tolhurst

Clonal plantings within the past several years have demonstrated that young tea is capable of more rapid development than at one time seemed likely. To obtain the best results, careful attention to every stage of the planting operation is essential but manuring represents one of the more easily controlled factors. This note gives what are believed to be generous recommendations, so that manuring need not be a limiting factor at any stage between planting and the time when crop yields have steadied down at maturity. Tea planted specificially as mother bushes requires slightly different treatment, due mainly to the different planting density (Kehl, 1961).

**Young Tea Manure Mixture**

T. 200

100 parts by weight—Sulphate of ammonia (20.6% N)
50 parts by weight—Saphosphosphate (27–28% N)
25 parts by weight—60% muriate of potash
25 parts by weight—24% magnesium sulphate

At 10.3% N, 9.7 lb. contain 1 lb. N.

It is suggested that the name T. 200 be retained even though alternative components are used, *e.g.* 50% muriate of potash, ammonium sulphate/nitrate (26% N), etc. The nitrogen content of such mixtures should be quoted, and the rates of application varied accordingly, if practicable. It is doubtful if urea would be a suitable source of nitrogen, particularly under very wet conditions and for very small plants.

We do not, of course, exclude organic manures, nor compound inorganic manures. Some of the latter, being granulated, may be found advantageous especially where tea is pegged down. Risk of damage to the foliage, by direct contact, may be lessened.

The original high-phosphate content is retained. Future modifications to this mixture will almost certainly be influenced by the varying nutritional requirements of individual clones. Until we have sufficient evidence to formulate separate mixtures, if it should be practicable to do so, we have decided to leave T. 200 unchanged.

**Method of application**

1. "Little and often" is the first rule to be adopted, especially in the earliest years when the root systems are very small.

2. Secondly, manure must be placed where the expanding root systems can reach it. This will mean in practice that a ring of manure should be placed with the branch-spread marking the outer limit, leaving a clear space round the stem to avoid bark scorching. The original rings will change to bands along the rows as the branches develop. Pegging may aggravate the risk of manure scorch to the foliage and, more serious, to the bark unless the pattern is arranged to allow distribution of manure between the branches. Branch-spread in pegged bushes may not be a reliable guide for the placement of manure, as the shoots are likely to extend beyond the reach of the roots.

3. A light dibbling, preferably with a stick, is recommended (Tolhurst, 1959).

**Rates of application per plant**

In the following table the higher frequency is preferred, but there is no point at all in increasing the frequency if that would bring some applications into very wet weather.

First year in the field

Starting as soon after planting as possible
4 doses each of $\frac{3}{4}$ oz. per plant or
6 doses each of $\frac{1}{2}$ oz. per plant.

Second year

4 doses of 1 oz. or
6 doses of $\frac{3}{4}$ oz.

Third year

3 doses of 2 oz. or
4 doses of $1\frac{1}{2}$ oz.

On a planting of 5,000 bushes per acre the above rates are roughly equivalent to annual rates of

90 lb. N
120 lb. N
180 lb. N per acre.

Fourth and following years

It is suggested that the rate for the third year be continued until the yield obtained "catches up" with the manure output, on a 10 lb. ratio (N to 100 lb. made tea). For example, if manuring continues at 180 lb. N per acre, then as soon as the yield for any one year reaches 1,800 lb. made tea, provision may be made for increasing the manure in the following year. This can only be done by anticipating the probable yield in the light of the evidence on the spot.

If, in the above example, a clone or a clearing should show no signs of reaching 1,800 lb., manure should be reduced gradually, say by 10% per annum, until a safe

maintenance ratio is found. This reduction should only be made after it is quite certain that the yield cannot be increased.

First full cycle

In the pruning year the tea may conveniently receive manure at the same rate as in the preceding year. Thereafter manuring in anticipation should be feasible, as the pre-pruning yields will give a good guide as to the yield levels likely to be obtained. The 10 lb. expansion ratio may conveniently be retained in this cycle.

Our own experience at St Coombs has shown that, in this period, frames and cropping capacity of many types of clone have been able to develop rapidly at a manuring ratio of less than 10 lb. N. There should be no reason to fear that the bushes will suffer if they outstrip their manure allocation for a short period, provided that earlier treatment has allowed vigorous frames to develop.

A change in the manure mixture may be made in this cycle to the appropriate mixture in the T. 700 series (Tolhurst, 1961). If desired to retain the high potash even for high elevations, it will be noted that T. 725 has the same N/K ratio as T. 200, and that 1.38 lb. of T. 200 are equivalent on a *nitrogen* basis to 1.0 lb. of T. 725.

As soon as T. 200 is abandoned in favour of one of the mature tea mixtures, dolomite should be applied, according to the highest rate of 130 lb. per acre per annum (Tolhurst, 1959a).

## Future Developments

Our experiments will, from time to time, enable us to improve upon the above guide, but certain points may be emphasized in advance.

Many clones show magnesium-deficiency chlorosis on the lower leaves, particularly in the early years when growth is rapid. As long as the chlorosis does not extend to the upper leaves, we are of the opinion that there is probably no need to increase the magnesium content of T. 200 in order to try to remove all the symptoms.

Clone TRI 2023, and less markedly 2024 and 2025, commonly shows very pale yellow-green upper foliage with occasional pink colouring indicative of nitrogen deficiency. The rates suggested above may not be sufficient, under some conditions, to prevent such deficiency. For these and related clones, generosity with T. 200 in frequent small doses is certainly advisable in the first few years.

Phosphate will doubtless be reduced in time, and dolomite may be increased. Both these modifications are likely to apply after the first pruning, rather than before.

We would encourage experiments on differential manuring of individual clones.

## References


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Tolhurst, J. A. H. (1959a). Revised suggestions for dolomite and magnesium applications to tea. *Tea Quart.* **30:** 48–49.

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# POTATO CULTIVATION ON ESTATES

T. Visser

Replanting of old tea is expensive partly because it has to be preceded by an unproductive period of reconditioning. The cultivation of a single crop of potatoes —after uprooting the tea and before planting the grass—may help to lower costs appreciably, while simultaneously augmenting food supply. Under reasonably favourable circumstances, such as generous manuring, an average-to-good fertility of soil, soil conservation measures, and careful control of pests and diseases, a net profit up to Rs. 1,000 per acre is possible in a 3-month period. The great advantage of using old tea land is that, judging by our pilot trials, such land appears to be free of the destructive *wilt disease*.

Although the prospects of growing a single crop of potatoes on tea land seem to be good, no data are available on estate-scale cultivation. With proper care, it is not very likely that potato cultivation will have an adverse effect on the young tea planted subsequently, particularly when manuring is sufficient and when potato cultivation is followed by grass; nevertheless this aspect needs investigation. Detailed information on the economics of the matter is also needed as regards yields per acre on the one hand and costs of fertilizers, costs of chemicals for control of pests and diseases, labour costs, etc., on the other.

For these reasons it would be of great assistance if estates tried out, in a limited way, potato cultivation in uprooted tea land while keeping a careful account of both costs and returns. It is therefore suggested that interested estates (above 3,000 ft) plant $\frac{1}{4}$ acre of each of the two varieties—*Gineke* and *Tedria*—of which seed potatoes will be made available at reasonable cost.

Both the Department of Agriculture and the Institute desire to obtain more information on the practical possibilities of potato growing on tea land. It is requested that those estates which are willing to participate in this scheme send the appended forms to the respective addresses. This is necessary in order to enable us to reserve the required stocks of seed potatoes and also because it is intended to give participating estates assistance in carrying out their potato cultivation successfully. It is also proposed to investigate, later on, the effect of previous potato cultivation on the subsequent growth of the tea clones, following the reconditioning of these areas. For that purpose it would be desirable for the potatoes to be grown in two blocks alternating with two adjacent blocks which will carry *only* grass.

It may suffice for the moment to give a brief outline of the requirements; more extensive information will be sent to participating estates at a later date.

(*a*) Only areas (above 3,000 ft) which are neither too steep nor too low in soil fertility should be chosen.

(*b*) Uprooting of tea should be done at such a time as to enable the potatoes to be planted between the end of October and the beginning of December.

(*c*) The potatoes should be planted along the contour in shallow trenches in which compost, if available, and fertilizers are placed shortly before planting.

(*d*) After digging up the potato crop—which should occupy the land for not more than 3 months—plant Guatemala grass as usual.

(*e*) The estimated costs of seed potatoes and fertilisers total Rs. 400–500/acre; the guaranteed price of potatoes is 20 cts./lb. at the estate. Exact costing will be valuable.

# LETTERS TO THE EDITOR

## PLANTING DENSITY AND PRUNING

A topic of conversation frequently heard amongst planters these days is that of planting density in new clearings. Connected with this are the questions of whether to 'bend' or 'not to bend', clones to be used, and the optimum size of each block of one clone. Perhaps the time has come to initiate some general discussion on these matters so that the views of those who have some experience can be aired.

Most first clearings tended to be planted at about 4′ × 2′ but, because of the extremely vigorous growth of nearly all the clones so far planted on anything approaching a commercial scale, many planters came to the conclusion that wider spacing was required. As far as distance between rows is concerned, the limiting factor is the distance a plucker can reach and it was after taking this into consideration that some planters came to the conclusion that the optimum distance between rows was about $4\frac{1}{2}$–5 ft. Most of the clones used now were selected for their spread and vigour in the field in the first instance and most of them are quite capable of covering this distance, whether pegged down or allowed to grow 'naturally'. The distance between plants along the rows varies from 1 to 3 ft.

There are planters who are very strongly opposed to 'Bending and Pegging', their reasons being generally given as follows:—

1. Most clones, having been chosen for their spread, will branch out naturally enough without artificial aid.

2. When the frames have been pegged out and the plants allowed to run up into plucking, the tendency will be for branches to be formed at the centre which will grow away, leaving a very large, mainly uproductive fringe.

'Benders' counter this arguments by saying:—

1. One of the most important requirements in tea cultivation is to keep the soil covered as much as possible. By bending over, the bushes are encouraged to cover the soil as quickly as possible, which they then do far more quickly than if left alone. In any case, it is far better to train a future frame in the shape of a 'saucer' rather than a 'wineglass'. When a 'saucer-shaped' frame comes to be pruned the full spread can be retained; but pruning a 'wineglass' leads to a drastic reduction in spread and, if the original stem has elongated, may lead to virtual collar-pruning becoming necessary.

2. After a 'saucer' had been pruned, growth will then tend to be more vertical, resulting in a plucking table which is nearly 'all centre', *i.e.* the growth around the periphery will match more closely that near the centre.

Another point of argument is on the density of planting and there are those who say that the way to obtain the maximum yield is to plant very much closer than even 4′ × 2′. As close a spacing as 3′ × 1′ has been talked about. It has

long been known that the centre of the bush yields very much more than does the periphery and the theory is that, by planting more bushes, more centres are thereby produced, leading to higher yields. Tables showing the results in both Indonesia and India have been published in support of this contention (Visser & Tillekeratne, 1958).

Arguments against this very close spacing are heard and include the following:— There is no doubt that in the first few years the yield from a closely planted area will exceed that from one in which the plants are more widely spaced, but there is a feeling that the more widely spaced area will overtake the other after say two pruning cycles. The figures quoted by Dr Visser rather indicate this. Unfortunately both experiments were discontinued but there were already indications that the yield curves would have crossed if the experiments had continued much longer. Because of more vigorous growth, clonal material is likely to show this trend sooner than the tea grown from seed. There is also heard the suggestion that closer planting would not produce any more 'centre' area but that the centres themselves would be smaller in proportion. It is of no avail, for instance, to plant kale or cabbages closer than a given minimum depending on variety, etc., yields can very easily be decreased in this way.

The 'closer-spacers' point out that tea, being a tree, tends to grow straight upwards and that a plucking table is an artificially induced form of growth. They argue that it is therefore only the area immediately above the main stem which will grow with the maximum vigour. If, by plucking, growth at this point is inhibited, then more growth will take place at the periphery but the average growth over the whole table thus produced will never equal that of the centre alone. Let us therefore have more centres, they say.

'Wider-spacers' agree with the original contention, but say that the tree form of the tea bush has a natural spread, that the root system tends to match this spread and that very close planting will unnaturally crowd the top foliage as well as the roots, leading to competition for light and self—shading above the ground and competition for water and nutrients below. Because of this competition for water, the effects of a drought would probably be more pronounced in closely planted areas.

At the moment, most arguments can only be expressions of opinion not founded on proven fact but perhaps one or two of those now stated could be joined together to produce tentative systems of planting.

If it is taken as true that a primary requirement is to cover the soil as quickly as possible after replanting (and it will not generally be possible to thatch large clearings sufficiently after the first 18 months to 2 years) then either (*a*) plants must be pegged down if planted 4′ × 2′ or wider or (*b*) if not pegged down they must be planted closer together.

If (*a*), then the saucer-shaped frame produced is not likely to form embarrassingly large side-branches in the future, since after the natural spread has been achieved the tendency will be for the bushes to grow upwards. This will encourage more even growth over the whole plucking table.

If (*b*), then some special pruning technique will be called for to allow the movement of pluckers. The natural growth habit of the plant will be reduced but some form of 'wedge-hedge' pruning, leading to wedge-shaped or domed hedges being formed, could probably be introduced with advantage.

The above are a few of the points heard at recent discussions and the tentative conclusions are intended only as bases for further argument.

P. R. U. Easteal
*Superintendent.*

Gouravilla Estate,
Upcot.
8th April, 1961.

**Reference**

Visser, T. & Tillekeratne, L. M. de. W. (1958). Factors affecting the planting distance of tea. *Tea Quart.* **29**: 36–44.

# CLONAL NEW CLEARINGS: THE FIRST PRUNE

The time is approaching when a number of planters will have to decide when the first new clearings planted under the Tea Replanting Subsidy Scheme should be given their first prune.

The yields of these clearings and the yields of the individual clones are naturally followed with close interest, and if all is going well and the tea looks vigorous, there is a definite temptation to postpone the initial pruning in order to study these yield patterns for another year. Whether such postponement of the first pruning is in the best long-term interest of the tea is another matter.

It would appear that the first prune should be at a reasonably low level to allow for future upward prunings, and an ultimate pruning cycle of at least 5 years in up-country districts.

Vigorous clones growing under favourable conditions develop wood in a remarkable way, and any undue delay in undertaking the first pruning may well mean cutting into heavy branches and thereby inviting die-back. At this stage, high-yielding clones would seem to be susceptible to die-back, as presumably their vigorous habits are not conducive to the accumulation of carbohydrate reserves. The writer has personal and unhappy recollections of very severe die-back in clonal tea which was pruned at just over five years from planting. The wood was very robust, and perhaps the prune was too hard.

Perhaps this note will stimulate a policy of "better early than too late" for this most important operation—the first prune of clonal tea.

Charles R. Burnet
*Superintendent.*

Nayabedde Estate,
Bandarawela.
29th May, 1961.

# SUMMARY MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON, HELD IN THE GENERAL COMMITTEE ROOM OF THE PLANTERS' ASSOCIATION OF CEYLON, COLOMBO, AT 9 A.M. ON FRIDAY, 2ND JUNE, 1961

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*Present.*—Mr F. Amarasuriya (Chairman), Messrs V. G. W. Ratnayake, M.B.E., (Chairman, Planters Association of Ceylon), L. F. J. Smith (Chairman, Agency Section, Planters' Association of Ceylon), A. V. Richards, (Director of Agriculture), M. P. Amarasuriya, R. C. Bois, W. H. W. Coultas, L. C. de Mel, H. R. Fernando, D. E. Hettiarachchi, R. M. Macintyre, N. M. Sanders, R. C. Scott, C.B.E., R. D. Wedd, Dr D. L. Gunn, C.B.E. (Director, T.R.I.), Messrs G. A. D. Kehl(Administrative Secretary), and H. J. Balmond (Secretary).

## 1. Minutes of the Meeting of the Board held on 3rd March, 1961

The minutes were confirmed.

The Chairman welcomed Messrs V. G. W. Ratnayake, R. C. Bois and L. C. de Mel to the Board.

## 2. Matters Arising from the Minutes

(1) Appointment of Statistician

The Director reported that the Treasury had agreed to release Mr P. Kanapathipillai, on no pay leave for service under the Institute until the amending legislation was passed, after which he could join the service of the Institute without loss of his pension privileges.

The Board received the report.

(2) Educational facilities: Provision of School bus

The matter was discussed fully, and the Board agreed in principle with the proposals for running a school bus service to Nuwara Eliya and referred to the Administrative Committee the working of the details.

## 3. Membership of the Board and Committees

(*a*) Membership of the Board

The following reports were received:—

(1) Mr V. G. W. Ratnayake, M.B.E., became an *ex-officio* member of the Board on his election as Chairman of the Planters' Association of Ceylon with effect from 24-3-61.

(2) Mr Francis Amarasuriya became an *ex-officio* member of the Board on his election as Chairman of the Low Country Products Association with effect from 28-3-61, *vice* Mr E. Muttukumaru.

(3) Mr L. C. de Mel had been nominated to represent the Low Country Products Association with effect from 8th May, 1961, *vice* Mr Francis Amarasuriya, who had become an *ex-officio* member of the Board as Chairman of the Low Country Products Association.

(4) Mr P. A. Silva, C.C.S., Assistant Secretary, Ministry of Agriculture, was acting for Mr B. Mahadeva, C.C.S., during the latter's absence from the Island as from 11-5-61.

(5) Mr R. J. Gilmour had been re-nominated to the Board for three years commencing 23rd February, 1961.

(6) Mr R. J. Gilmour was on leave from 31st May, 1961 and Mr R. C. Bois would be acting for him during this period.

(*b*) Administrative Committee

Mr V. G. W. Ratnayake was appointed *vice* Mr E. Muttukumaru, who had ceased to be a member of the Board.

(*c*) Salaries Sub-committee

Mr L. C. de Mel was appointed *vice* Mr E. Muttukumaru who had ceased to be a member of the Board.

## 4. Finance

(1) Withered-leaf sorting machine: Rs. 7,000/-

The Board approved the supplementary provision of Rs. 7,000/-

(2) Hantane Sub-station: Capital expenditure—Rs. 14,338/23

The Board considered details relating to capital votes and expenditure incurred in providing office and stores accommodation, building a dam, etc. at Hantane Sub-station and approved the supplementary provision of Rs. 14,338/23.

(3) Marshall's Empire drier: Rs. 7,083/20

A vote of Rs. 7,083/20 was approved for repairs to the furnace.

(4) CR. 1 Machine

The Board considered a recommendation of the delegation which visited Tocklai for the installation of a CR. 1 machine at St Coombs for experimental use in the first instance and referred the matter to the Experimental and Estate Committee for further report.

The Board also recorded its appreciation of the hospitality and facilities offered by the Indian Tea Association to the Institute's delegation.

## 5. Minutes of the Administrative Committee Meeting held on 21st April, 1961, & Financial Appendix

The minutes of the Administrative Committee meeting held on 21st April, 1961 which had been issued under cover or Circular No. 1961/106-B of 17th May, 1961, were considered.

(1) Delegation of the functions of Chairman of the Board

The Board agreed that the Chairman of the Board be empowered to nominate a member of the Administrative Committee to act as Chairman of that Committee for such period as the Chairman may determine.

(2) The audited accounts of the institute as at 31st December, 1960 and the auditors' report thereon

Reported that the audited accounts of the Institute as at 31st December, 1960 and the auditors' report thereon which had been circulated to the Board under cover of Circular 1961/101-B on 27-4-61, had been considered in detail by the Administrative Committee, whose observations and recommendations were recorded in pages 2–6 of the minutes.

The Board adopted the audited accounts of the Institute for the year, 1960, and the auditors' report thereon subject to the observations and recommendations made by the Administrative Committee.

(3) Post of Low-country Adviser

The Board agreed that Dr A. W. R. Joachim's contract be renewed for a further period of two years as from 1st October, 1961.

(4) Buildings

On the proposal of Mr D. E. Hettiarachchi, seconded by Mr V. G. W. Ratnayake, the Board authorised the use of the Board's seal on the contractual documents relating to these tenders, subject to the contract for Intermediate Staff Quarters (female) being held up until the increase in cess was passed.

(5) Sale of Pembroke Bungalow

Reported that:—

(*a*) The Department of Agriculture had agreed to pay a rent of Rs. 275/- per mensem with retrospective effect from March 1st, 1959, the date the bungalow was taken over. Arrangements have also been made by the Director of Agriculture to give vacant possession of the house.

The report was received.

The Board then adopted the Minutes of the Administrative Committee meeting held on 21st April, 1961, including the financial appendix.

## 6. Minutes of the Meeting of the Economic Committee held on 3rd March, 1961

The minutes of the Economic Committee meeting held on 3rd March 1961 (Paper 1961/84-EC) which had been circulated under cover of Circular 1961/106-B of 17th May, 1961, were received.

A discussion on methods of further investigation followed and the Board passed a vote of Rs. 14,000 towards the expenses of such a reconnaissance survey of all aspects of the project.

## 7. Minutes of the Meeting of the Experimental and Estate Committee held on 6th May, 1961 & Financial Appendix

The minutes of the meeting of the Experimental and Estate Committee held on 6th May, 1961 which had been circulated under cover of Circular No. 1961/106-B of 17th May, 1961, were considered.

(1) Survey of St Coombs

Reported that arrangements for a broad over-all survey of St Coombs were being made and it was proposed that the survey should be done immediately after the monsoon, the approval of the cost of the survey to be obtained by circulation of papers. Approved.

(2) Consulting Engineer

The recommendation that Messrs H. W. Hammond and Company be appointed consulting Engineers, and that provision be made for this service in the 1962 estimates was approved.

(3) Circulars

Agreed that all circulars such as that on T. 700 (1961) should be circulated to the Board.

(4) Extension to the factory

The Board directed that such matters should come under the direction of the Buildings Committee.

The minutes of the meeting of the Experimental and Estate Committee held on 6th May, 1961, were then approved.

## 8. Staff Matters

(1) Appointments

Paper 1961/120-B listing appointments and resignations was received.

(2) Acting Director

The Board decided that Dr A. W. R. Joachim, Low-country Adviser, be Acting Director during the Director's absence on leave from 19th June to 29th July, 1961 (inclusive).

(3) Mr S. Nagarajah: Technical Assistant, Plant Physiology Div: Scholarship

The Board approved the recommendation that Mr S. Nagarajah be allowed to use a U.S.O.M. Scholarship to do advanced training in analytical chemistry with special reference to plant biochemistry, with or without an M.Sc. degree, although he did not have the prescribed service qualification of five years.

(4) Mr J. V. Sabanayagam, Technical Assistant, Advisory

The Director reported that Mr Sabanayagam had obtained First Class Honours in the B.S.A. examination (Ontario), being one of 19 in that Class out of 107 passes.

The Board recorded its appreciation of Mr Sabanayagam's creditable performance, to be notified to him.

## 9. Other Business

(1) Annual Report of the Board 1960

Reported that approval of the annual report for 1960 had been obtained by circulation of papers.

(2) Licence for renewal of electricity

The Board authorised the use of its seal on the new agreement for electricity to St Coombs.

H. J. Balmond
*Secretary*

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